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A REMARKABLE OCCURRENCE OF THE FLY, BIBIO FRATERNUS LOEW.

JAMES G. NEEDHAM.

NOT far from my home in Lake Forest there is a forty-acre patch of woodland pasture that has been enclosed but not grazed for a number of years. It has become well overgrown with a thick blue-grass sod. Save for a few young hawthorns in scattered clumps, there is no underbrush. The open wood consists mainly of white oaks. Black oaks were originally abundant but have been cut down, and now the sod is thickly dotted with their rotting stumps. Around the bases of these stumps, where the sod closely enwraps them, is the larval home of *Bibio fraternus*.

I had seen but few specimens of this fly until the spring of 1901, and was wholly unacquainted with its immature stages and with its larval habitat. It chanced that on walking across this pasture in April I kicked over a rotten stump, and, where a lateral root pulled out from under the sod, there in the fine black soil that had resulted from the complete decomposition of the bark were a large number of dipterous larvæ, which later, when reared, yielded imagoes of this species.

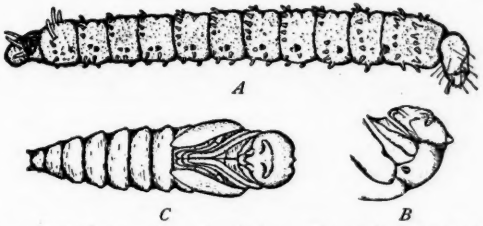
Nothing appears to have been written of the species since Loew penned the original description. In fact, the immature stages seem not to have been described or figured for any American species of the family Bibionidæ. Mr. D. W. Coquillett, who determined my imagoes for me, having assured me that under the existing circumstances even a slight contribution to the knowledge of these things would be welcomed by dipterologists, I offer herewith some observations on the habits of this species and a description of its immature stages.

Habits. — My acquaintance with the habits of the species began as indicated above. On May 5 I collected a large number of grown larvæ and a few pupæ about different stumps and placed them, with a quantity of their native soil, in a breeding cage. Imagoes began to appear on the 13th and continued transforming until the 20th. On the 18th, when my cage was full of fresh imagoes, I went out to the pasture but could find none there. In the earth were plenty of pupæ, but no more larvæ. Perhaps the development of those in my cage was hastened by the higher temperature of the laboratory in which they were kept. About May 22 the first few imagoes were observed at large. On the 24th I discovered, on walking across the pasture, that the grass was full of them. A score could be swept up at each stroke of the net; but none were flying, for the air was chill. On the 26th, 28th, and 30th, visiting the pasture again I saw the great swarms of them which I now come to describe.

I was not prepared for any exhibition of aërial activity by what I had seen in my breeding cage. There the imagoes seemed hardly able to walk, to say nothing of flying. They were very sluggish ; they climbed the sides of the cage weakly, and tumbled about even in walking, and were handled without any thought of their getting away. Even in the field on the 24th I had picked them up with my fingers and examined them unconfined under a lens. But on these three later days warm sunshine had stirred them to unexpected activity. They were flying in countless numbers in the more sheltered places in the woods and were actively climbing about in the branches of the opening blue-grass panicles or resting in pairs on the

leaves. The flight of the males is long sustained. Both males and females, and especially the latter, have some difficulty in getting launched. They climb to a leaf top, balance carefully, stretch their wings and try them before letting go, and finally swing free into the air.

I have rarely come upon a scene of greater animation than a sheltered hollow in this wood presented. There was the undulating field, clad in waving grass and set about with the pale-hued springtime foliage of the white oaks; there were the flowering hawthorns; and there were the myriads of Bibios floating in the sunshine, streaming here and there like chaff before sudden gusts and swirls of air. All the spiders' webs



A, larva of *Bibio fraternus* Loew., lateral view. *B*, lateral view of head of female pupa. *C*, ventral view of male pupa.

in the bushes were filled with captives; little groups of ants were dragging single flies away to their nests, and once I saw overhead a chestnut-sided warbler, perched on a bare bough directly in a stream of passing flies, rapidly pecking to right and to left, persistently stuffing his already rotund maw.

I stood in one spot and swept the air with my net for half a minute and obtained 128 male Bibios and 5 females: ratio, 25: 1. I swept the grass a few times with my net and thus obtained 127 males and 372 females: ratio, 1: 2.2. The discrepancy of ratios is due to the fact that a comparatively small proportion of the flies were in the air. I counted a number of flies I could see resting on the grass in several small areas wide apart and found the counts averaged 15 Bibios per square foot; and there were here in one place forty acres of such Bibio territory.[1] There can

[1] Professor Herbert Osborn notes the occurrence of *Bibio albipennis* in phenomenal numbers in Iowa, in *Insect Life*, vol. iii (1891), p. 479.

be no doubt that this obscure and little-known fly is a factor of considerable importance in the ecology of such a situation.

Immature Stages. — I now describe the larva and the pupa, and accompany the descriptions with drawings by Miss Maude H. Anthony.

Larva. — Length 13–14 mm.; diameter 1.5 mm. Body cylindric as far as the 9th abdominal segment, or with slightly greater depth in the thorax; head well developed, exserted, about equal in length to the body segments, except the first, which is a third longer than the others; there is a distinct Y-shaped suture on the top of the head; a pair of setæ are inserted just before and another pair just behind the clypeal suture; eyes wanting; four setæ on the epicranium each side, — two at the edge and one above and one below; there are lesser setæ on the maxillæ externally. The laciniæ of the maxillæ and the mandibles are elongate pyramidal, with low teeth on their truncated apices. There are two pairs of thoracic and eight pairs of abdominal spiracles: the foremost is situated at the rear of the prothorax and is larger than those following, except the last; the second pair is at the front margin of the metathorax; the next seven pairs are just before the middle of abdominal segments 1–7; those of the 9th abdominal segment are very large and each is divided by a median groove. Each of the middle body segments is completely encircled by a row of about a dozen tubercles, which is slightly oblique upon the sides and in which the dorsal tubercles are usually longer than the ventral, and there are a few tubercles out of line at the sides in the vicinity of the spiracle; on the 1st segment behind the head there is another row of eight tubercles, on the dorsum between the spiracles, and on this segment the tubercles are all longest at the sides; on segment 8 of the abdomen the dorsal tubercles are more elongate and the ventral ones more reduced; segment 9 is depressed conic, tapering posteriorly, with the large spiracles inserted in anterior emarginations of a brownish, chitinous, saddle-shaped plate, which covers most of the dorsum of the segment; behind this plate arise two pairs of filaments (elongate tubercles), the median pair as long as the segment is thick, the external pair a third shorter.

Skin granulate, closely invested with adherent dirt particles.

Pupa. — Length 7.5 mm.; breadth of thorax 2.1 mm., of abdomen 1.5 mm. Body smooth, whitish, with low appressed head, short, thick thorax, and straight abdomen whose sides are parallel except at its abruptly tapering apex.

Head flat, with short antenna cases which extend hardly more than halfway across the eyes, with well-marked paired jaw cases, and with an ocellar tubercle at the rear of the head above, low in the male, high and prominent in the female (owing to slight development of the compound eyes).

Prothoracic spiracles low, not elevated above the thoracic dorsum; no respiratory horns or trumpets.

Ninth abdominal segment terminating on the dorsal side in a pair of stout divergent triangular processes, that are about as long as the segment which bears them.

The rather generalized larva is characterized by an unusually well-developed head, simple mouth parts, rings of tubercles on all the segments, those of the two hindmost segments elongate, becoming filaments, showing out of what material the borders of the tipulid caudal respiratory disk have been made. The pupa is characterized by the unusual brevity of the antenna cases, which reach but halfway across the eyes, distinctly paired jaws, low prothoracic spiracles without respiratory trumpets, horns, or tubes, and a naked, spineless skin.

AN UNUSUAL OCCURRENCE OF DINOFLAGELLATA ON THE CALIFORNIA COAST.

HARRY BEAL TORREY.

DISCOLORATIONS of the sea due to the presence of minute organisms, and often many miles in extent, have been seen in various parts of the world, along the shore and in the open sea. Deep-water sailors are familiar with such appearances, which they call "whale food," or "brim." The cause of the color is not always the same organism, though perhaps most frequently some species of Dinoflagellata, in enormous numbers.

This phenomenon was observed at San Pedro, Cal., during the present summer, and, according to the testimony of old residents, for the first time in that region. Something of the sort is said to have been noticed in Tomales Bay, some five hundred miles farther northward, in the early seventies. These are, I believe, the only known instances of its occurrence on the California coast; so that its rarity alone seems to demand a recording of the few notes taken during this last appearance.

It was first noticed on July 7 as a red streak off the mouth of San Pedro Harbor. During the next few days it approached the shore, changing its shape and dividing into several patches, each many acres in extent. On the 16th it reached the shore, and was the cause of a most unusual display of phosphorescence, which reappeared many evenings in succession. The phosphorescent water was found to contain vast numbers of a peridinian which I have referred tentatively to the genus Gonyaulax (see description below), and which gave it its red color during the day. Under the microscope Gonyaulax responded with a flash of light to any marked disturbance of the water containing it. At this time Noctiluca, so abundant later on, was not noticed. Wherever the ocean waters were roughened the wavelets were crested with green-blue light. In the quiet waters of the harbor the fishes, pelagic worms, and crustaceans traced trails of fire.

On the 20th, four days after the red (characteristically a muddy vermilion) streak had reached the shore, a most sickening odor arose from the water along the beach. On the 21st it was almost unbearable. During the night, on a beach about four hundred feet long, a large number of animals were left by the tide. Among them were several hundred holothurians (*Trachostoma arenata*), several specimens of two species of sting ray (*Mylobatis californicus* and *Urolophus halleri*), two species of guitar fishes (*Rhinobatus productus*, 3 individuals; *Platyrhinoidis triseriatus*, 3 individuals), two cestracionts (*Gyropleurodus francisci*), two dogfishes (*Galeus californicus*), a red perch, a large number of smelts, and several octopi. The fishes and octopi were dead, but many of the Trachostoma lived for several days. Many *Pinnixa faba* had crawled out of the cloacæ of the holothurians, on which they are normally parasitic.

On the 22d more Trachostoma were left on the beach. Some days later the odor had almost disappeared, but the water in the harbor and along the beaches was a brilliant vermilion. It was at this time that on two succeeding mornings a number of specimens of the blindfish (*Typhlogobius californicus*) were thrown up, both alive and dead. Then for two days came a number of *Tevila crassatelloidis*, many *Petrolisthes cinctipes* and *Cancer antennarius*. Finally, great numbers of *Hippa analoga* were thrown up, most of them alive but apparently debilitated and unable to dig as is their habit. They were mostly of large size.

This wholesale destruction was entirely unprecedented for the summer. The height of the tide and breakers were but subordinate causes at best; for, although the holothurians and selachians appeared after a higher tide and stronger sea than usual, as many of the former came up on a beach protected by a breakwater as on the beach shown in the photograph (Fig. 1). And as the tide fell from day to day, the animals did not cease to appear. The Typhlogobius appeared when the tide was moderate, with practically no sea running. This is interesting, not only because Typhlogobius usually lives, undisturbed by breakers, in holes and crannies among the rocks, which must

have been in this instance some distance from the beach, but also because it has never before been reported from San Pedro. The Gonyaulax served here as a means of discovery.

The above facts have been enumerated because they exhibit in a striking way a natural cause in process of eliminating the unfit of several and diverse species, which are resisting with various degrees of persistence and success. Whether this elimination is promiscuous, or correlated with variation from the type

FIG. 1. — Beach covered with dead animals, mainly holothurians with several selachians in the foreground; a result of the appearance of Gonyaulax.

of the species, is a question for whose solution material has been collected by Dr. F. W. Bancroft of this laboratory.

The "red water" occurred for two hundred miles at least along the coast, from the region of Santa Barbara to San Diego, and extended several miles to sea. It was still present around San Pedro on September 1. Wherever it was seen the fishermen reported a scarcity of food fishes. The small harbor fishes seemed to be unaffected by it, and the tiny invertebrates of the plankton were abundant in it. Noctiluca appeared in great numbers toward the end of July, and devoured Gonyaulax with

avidity. There were more copepods in the red streaks than in the intervening bluer water. I was not able to see any Gonyaulax in them, however.

Gonyaulax undoubtedly produced its harmful effects by dying in enormous numbers, the putrefactive changes thus occasioned polluting the water and giving rise to the stench already mentioned. It died most rapidly along the water's edge, thus affecting the littoral animals especially.

When placed under the microscope for examination in a drop of water, many Gonyaulax soon became quiescent, and the protoplasm drew away from the cuirass, forming a spherical cyst, which was often discharged by a rupture of the cuirass along any sutural line. Others died outright and disintegrated, leaving only the transparent, colorless cuirass. This tendency to die readily was noted long ago by Darwin for a species of dinoflagellate found in swarms off the western coast of South America.

With this enormously abundant species other species of Dinoflagellata were found: *Ceratium furca, C. fusus, C. michaelis, Peridinium divergens, Prorocentrum micans,* Polykrikos *sp.*, Dinophysis *sp.*, Noctiluca *sp.*, and certain swarmspores resembling those of *Peridinium ovatum.* The most abundant of these was Noctiluca, toward the end of July, but it did not begin to approach Gonyaulax in numbers. Where there was one Noctiluca there were hundreds, if not thousands, of the other form. The latter was present in the tow as early as June 17, in company with, and about as abundant as, the above-named species. All of these species increased during July, but Gonyaulax outstripped the others remarkably. The cause of this increase of one species over these closely related and associated species is not clear. I did not see a single case of fission, but the individuals varied so greatly in size as to suggest rapid reproduction, probably by encystment and spore formation, though no spores excepting the large Peridinium (?) swarmspores were seen. Noctiluca was sporulating at this time. It is possible that the immense patches of Gonyaulax were brought in by currents from deep water. Nothing, however, was seen of them throughout the season around Santa Catalina Island,

some twenty miles to sea. And if this were so, the cause of the rapid reproduction would still remain obscure.

The boundaries of the red streaks were quite sharply marked, although the water between streaks often contained Gonyaulax in abundance. Temperatures and determinations of salinity were taken at the surface and at the bottom of both red streaks and water entirely free of Gonyaulax. The readings averaged the same in all cases for the same depths. Soundings with a rather crude water bucket indicated that Gonyaulax was present approximately in as great abundance at the bottom at the depth of six fathoms as at the surface.

The key to the problem lies, I believe, in the chemical constitution of the water, since, aside from a sensitiveness to chemical

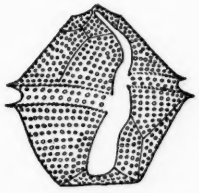


FIG. 2.

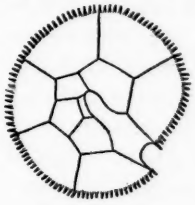


FIG. 3.

FIG. 2. — Gonyaulax, showing both longitudinal and transverse furrows.
FIG. 3. — Gonyaulax from upper pole, showing arrangement of anterior plates.

stimuli which it possesses in common with all living things, Gonyaulax is holophytic, if its color is a safe criterion. Zumstein has recently shown that the chlorophyll-bearing Euglena may lose its color under appropriate conditions and change its method of feeding in consequence to the saprophytic type. The *C. michaelis* and Polykrikos *sp.*, as well as the Peridium (?) swarmspore, found with Gonyaulax, were colorless. Not only, then, within the limits of one family of protophytes do two methods of nutrition exist, but in a single species, and possibly in a single life cycle. But the question of the source of the food of marine organisms is too vast a subject to be attacked with the scanty materials at hand. Whether Gonyaulax is nourished by inorganic or organic solutions, and whether a variation in food supply is the explanation for its unusual abundance, are problems to be solved by future experiment.

I have called the dinoflagellate with which these notes are chiefly concerned Gonyaulax, because in the first place it approaches that genus very closely, and in the second place such a small amount of the literature of the group is accessible to me that I do not feel warranted in erecting a new genus for it. It differs from Gonyaulax as described in Engler and Prantl's *Die natürliche Pflanzenfamilien* only in that in the anterior moiety of the cuirass there are six intermediate plates instead of five, and four end plates instead of three.[1] It may be described as follows (Figs. 2, 3):

Body divided by the equatorial furrow into two subequal halves, each of which is a low cone, the posterior one truncated. Anterior cone formed by six large intermediate plates meeting four much smaller unequal end plates in an angle somewhat less than one hundred and eighty degrees. Posterior cone of five large intermediate and one large end plate, with a narrow accessory plate next the longitudinal furrow. Equatorial furrow slightly oblique, deep, with toothed edges. Longitudinal furrow broader posteriorly than anteriorly, extending from the edge of the posterior end plate to the apex of anterior cone. All plates regularly bossed. Sutural lines raised into high, narrow ridges.

The equatorial flagellum alone is active in ordinary swimming, producing a rapid rotary and forward movement. The other, which trails behind during such progress, is responsible for the spasmodic jerkings occasionally seen.

The size of the cuirass varies from 25 μ in diameter by 29 μ in length, to 53 μ by 56 μ. Cysts average 24 μ in diameter. They are almost spherical, with granular contents of a brown-green color. Cuirass itself colorless.

ZOÖLOGICAL LABORATORY, UNIVERSITY OF CALIFORNIA,
September, 1901.

[1] Since the manuscript was sent to press I have found that Bütschli (Bronn's Klassen und Ordnungen) has noted a similar discrepancy between the original description of Gonyaulax and his own observations, which leads me to suspect that the genus was wrongly defined by its author.

REGENERATION IN HYDRACTINIA AND PODOCORYNE.

ANNAH PUTNAM HAZEN.

In a paper entitled "Experiments in Regeneration and in grafting of Hydrozoa,"[1] Peebles has given the results of some interesting experiments with Hydractinia and Podocoryne. These two hydroids are found at Woods Hole on the shells inhabited by hermit crabs. Each colony consists of three different kinds of individuals, namely, the nutritive, the reproductive, and the protective (a low cone-shape growth extending over the hydrorhiza is considered by some authors to constitute a fourth class of individuals). The experiments described by Peebles were confined to the first three classes. The well-marked characteristics of the different kinds of individuals make it possible to distinguish between them even when the polyps are immature or incompletely regenerated. The knoblike tentacles of the reproductive polyps appear during regeneration earlier than the reproductive organs, and the long, slender tentacles of the nutritive polyps can be easily distinguished from those of the protective individuals, which contain nematocysts. Peebles found that polyps freed from the hydrorhiza would live for days in small dishes containing sea water and quickly regenerate lost parts. Pieces of the stalk of these three classes of polyps, from which the heads had been cut, regenerated new heads of the same kind as those that had been removed. Small pieces cut at different levels from the stock of nutritive and protective polyps regenerated at one end a head like the one removed. Not infrequently a head appeared at both ends of a short piece. Without exception, the regenerated heads had the same characteristics as those that had been removed, and no constant variation in time or capacity for regeneration at the different levels was observed.

[1] *Archiv für Entwickelungsmechanik der Organism*, Bd. x, Hefte 2, 3.

Nutritive polyps cut from the hydrorhiza were grafted by Peebles in pairs, either by their oral ends (after removing both heads) or at the aboral ends (with both heads attached), or the aboral end of one individual was grafted to the oral end of another, from which the head had been removed. In all cases the line of union between the two components was soon effaced, the digestive cavities became continuous, and a complete union seemed to be effected. In all the experiments in grafting nutritive polyps, nutritive heads were regenerated at one or at both ends, and often also in the region of the graft. The union of different kinds of individuals was also successfully accomplished as follows: The aboral end of a nutritive polyp was grafted to the aboral end of a protective polyp,— the direction of the two components being thus reversed. After a few hours the nutritive head was removed, leaving a portion of its stalk attached to the aboral end of the protective polyp. The head which regenerated at the free cut surface showed markedly the characteristics of the nutritive individual and did not seem to be in the least affected by union with the protective polyp. Similar grafts were made with nutritive and reproductive polyps, followed by a removal of the reproductive head. Here, again, the regeneration of a reproductive head at the end of the stalk showed no modification due to the union with a nutritive polyp.

The results of these experiments by Peebles suggested the following questions: first, Would the fixation by means of stolons of one of the components of the graft alter the result? second, Would the kind of regeneration that took place be affected by the relative orientation (with respect to the polarity) of the pieces? With these questions in mind, I carried out the following series of experiments at the Marine Biological Laboratory during a few weeks in July and August, 1901.

Both Hydractinia and Podocoryne were used, and the method of grafting was similar to that employed by Peebles. It was found to be of importance to use fresh material, since that kept for several days in the aquarium regenerated more slowly and less constantly than material just brought in. A few experiments like those described by Peebles were repeated

and similar results obtained, although most of the grafts were made by joining the aboral end of a reproductive polyp to the oral end of a nutritive stalk, the head of the latter having been previously removed. In this way the direction of the two components was the same, instead of reversed, as in Peebles's experiments. The pieces were allowed to remain undisturbed for a short time after grafting, or until the tissues had become united, so that the reproductive head could be cut off without danger of separating the grafted pieces. Better results seemed to be obtained if the head were removed within a few hours after union, so that the process of regeneration started in the first night after the graft had been made, although satisfactory results were sometimes obtained when the cut was made on the second day. Fig. 1 represents a typical experiment of this kind. An immature reproductive polyp (*r.*) was selected and grafted at its aboral end to the oral end of a nutritive stalk (*n.*) from which the head had been removed. The tissues joined, and a few hours later the reproductive head was removed, leaving the two components of nearly equal size. Within twenty-four hours a complete reproductive head had regenerated (*rh.*), which showed no modification due to the influence of the stalk of the nutritive polyp.

FIG. 1.—×45. The aboral end of an immature reproductive polyp (*r.*) was grafted to the oral end of a nutritive stalk (*n.*) August 3. A few hours after the union, the reproductive head was cut off, as indicated by the dotted line. The next day a reproductive head (*rh.*) had regenerated on the end of the reproductive stalk. (Drawn August 5.) The arrows point toward the oral end of each individual.

When the union of the two components was incomplete and a part of the cut surface of the nutritive stalk was exposed at the side, tentacles or a whole nutritive head developed at this place, as shown in Figs. 2, 3, and 4, *nt.* This occurred frequently, as the nutritive polyps are often much larger than the reproductive polyps, and the latter, unable to cover the whole cut surface, unite with the nutritive only at one side. This did not prevent the body cavities of the two components from becoming continuous. The portion of the reproductive stalk (*r.*) used in the experiment shown in Fig. 2 was taken

from the oral region of a young individual, while the nutritive component (*n.*) came from the aboral region and shows a piece of a spine (*s.*) attached to its base. Although, in this case, the nutritive component was relatively much larger than the reproductive stalk, a head regenerated on the latter which showed no apparent influence of the larger component but possessed only the characteristics of the reproductive head.

FIG. 2. — × 45. The aboral end of a young reproductive polyp (*r.*) was grafted to one side of the oral end of a nutritive stalk (*n.*) August 3. A few hours later the reproductive head was cut off as indicated by the dotted line, leaving a small portion taken from the oral half of a reproductive individual attached. A reproductive head (*rh.*) regenerated at the end of the reproductive stalk and nutritive tentacles (*nt.*) around the end of the nutritive stalk. A piece of spine (*s.*) was attached to the base. (Drawn August 5.)

Another experiment is shown in Fig. 3 in which the nutritive stalk (*n.*) was many times larger than the small component taken from a reproductive polyp (*r.*). The latter was cut from the aboral region of an adult individual from which most of the generative buds had been removed.[1] Here, again, the union was complete, and again the regenerated head showed no effect produced by the larger component, but the new growth corresponded to what would probably have appeared on a reproductive stalk alone from which the head had been removed.

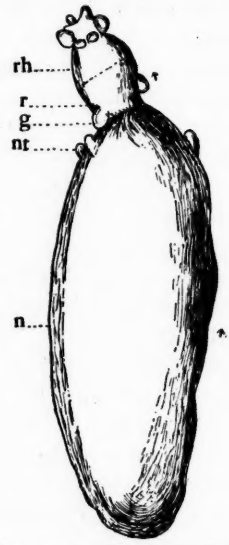


FIG. 3. — × 45. The aboral end of a reproductive polyp (*r.*) was grafted, July 25, to the oral end of a nutritive stalk (*n.*). Three hours later the reproductive head was removed at a place indicated by the dotted line. The reproductive component which remained was from the aboral region of an adult. Two generative buds (*g.*) were left attached; others had been removed. A reproductive head (*rh.*) and nutritive tentacles (*nt.*) developed. (Drawn July 27.)

Many similar experiments were made, from which these have been selected as typical. Considering that these different

[1] Two generative buds were left, as shown in Fig. 3, *g*.

individuals are organically connected, it seemed at the outset possible that, under certain conditions where a complete union was effected, the subsequent regeneration might be modified. This seemed especially likely to occur if the nutritive polyp, which is the more vigorous and the less specialized of the two, formed the larger component. Repeated attempts were made to leave as small a portion of the reproductive stalk as possible attached to the nutritive component, but, with one exception, none were obtained in which the regenerated head showed the influence of the nutritive polyp. The result is the same when the direction of the two components is reversed, as in Peebles's experiments, and when it is the same, as in most of my experiments (see Figs. 1, 2, and 3). All regions of the stalk from which the components are taken seem equally unable to influence the subsequent regeneration or to be influenced by the union. It was also found that the regeneration following a graft of this sort is no more easily influenced when the reproductive component is taken from an immature polyp than when it is taken from an adult.

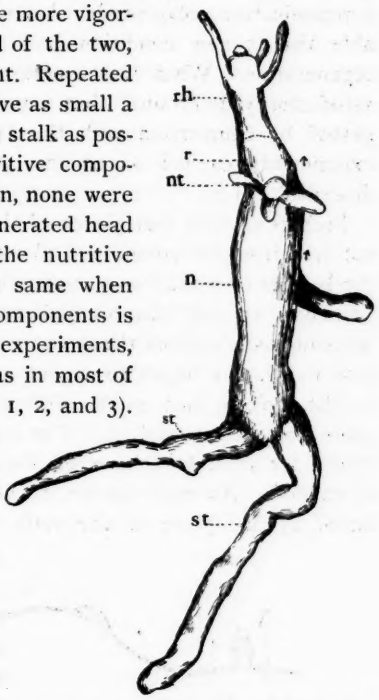


FIG. 4. — × 45. The aboral end of a reproductive polyp (*r.*) was grafted to the oral end of a nutritive stalk (*n.*) July 20. The reproductive head was cut off July 21, as indicated by the dotted line. The next day a nutritive head (*rh.*) had regenerated on the end of the reproductive stalk and nutritive tentacles (*nt.*) at the point of union between the two components. Stolons (*st.*) had also developed on the aboral end of the nutritive stalk attaching it to the disk. (Drawn July 23.)

An interesting and solitary exception to these results is illustrated in Fig. 4. A nutritive polyp (*n.*) and a reproductive polyp (*r.*) were grafted as in the preceding cases, and on the following day the reproductive head was removed, leaving only a small part of the reproductive stalk attached. A day

later a nutritive head (*rh.*) had regenerated on the end of the reproductive component and, at the same time, stolons (*st.*) had pushed out from the nutritive polyp, fastening it to the bottom of the dish. As this was the only instance in which a reproductive polyp produced a nutritive head, it was probable that a new condition had appeared and affected the regeneration. What this condition may have been was not satisfactorily determined, but a possible explanation was suggested by comparison with the results of another series of experiments carried on at the same time. These will be described below.

Peebles showed that pieces of the stalk of nutritive polyps cut free from the colony and allowed to remain undisturbed at the bottom of a shallow dish of water sometimes sent out long branching stolons, the original stalk becoming absorbed and indistinguishable from the newer growth. "After several days new individuals began to appear, growing up at right angles to the stolons, just as the different individuals of a colony grow from the hydrorhiza. The formation of new polyps continued for several weeks when the experiments were brought to an end. As many as ten to fifteen new polyps were produced by one piece of the stalk. These polyps were inva-

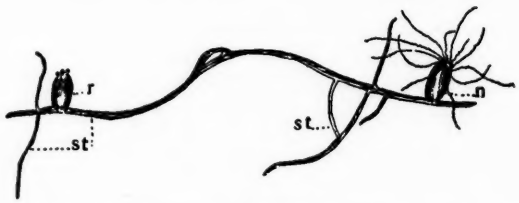


FIG. 5. — Represents a small portion of a colony which had developed from a nutritive polyp, showing a new nutritive polyp (*n.*), a reproductive polyp (*r.*), and stolons (*st.*). The original polyp had been absorbed. The colony was started July 24. The drawing was made August 3. The disintegration of the colony began August 8.

riably nutritive individuals, characterized by their long slender tentacles." I repeated this experiment and also used pieces of nutritive polyps as well as pieces of the stalk. The growth of a large number of colonies followed. New nutritive polyps were always the first to appear on the stolons,

but after the colony was well formed a few small reproductive polyps also grew out from the stolons at occasional intervals (Fig. 5). Although the colony lived for several days or a week after the production of the reproductive polyps, no signs of

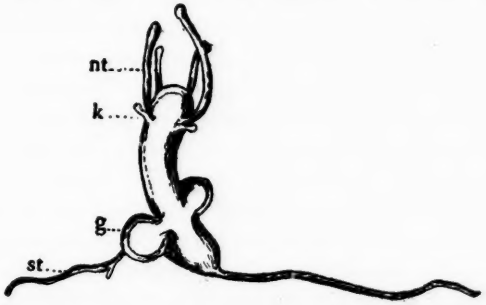


FIG. 6. — Represents a reproductive polyp which was cut from the hydrorhiza July 20. Several generative buds were removed; two were left (*g.*). The reproductive tentacles were replaced by four nutritive tentacles (*nt.*). Two small knoblike tentacles (*k.*) are seen below the nutritive tentacles. At the same time the nutritive tentacles were developing, stolons (*st.*) grew from the aboral end, fastening the individual to the disk. (Drawn July 23.)

developing generative buds appeared. Indeed, the life of the colony seemed spent, the stolons became more slender and broke apart, and the polyps died, one after another. During the period of growth the stolons often anastomose and two adjacent colonies become united. Such colonies are most easily started if whole polyps are cut off close to the hydrorhiza. A small piece of a polyp will lie on its side on the bottom of the dish, often producing new hydranths and changing its form, until it disintegrates, but rarely forms stolons.

In the same way reproductive polyps were removed and kept in dishes, with the hope that they would also form colonies. They sent out stolons much more slowly than the nutritive polyps did, and although a large number of individuals formed stolons, many of them died before new polyps had developed. It is probable that others, which seemed more vigorous, might have developed new polyps had more time been allowed them. In one dish in which half a dozen reproductive polyps had formed stolons a curious change was observed. The stolons had grown rapidly, and the hydranths

which had borne the small knob characteristic of the reproductive polyp showed, in three days, a remarkable development of tentacles like those on a nutritive hydranth, as shown by *nt.*, Fig. 6. Two small knobs (*k.*) are present below the ring of tentacles, and these may — or may not — represent those of the original reproductive hydranth. A few large generative buds had been removed from the polyp, but two remained as seen in Fig. 6, *g.* The polyps seemed vigorous, but possibly the presence of the generative buds caused an early disintegration. At all events, they all died before any new polyps were formed by the stolons. What the condition was which brought about this change was not determined, but it seemed possible that the formation of stolons might be connected with the development of nutritive tentacles. The growth of stolons in this case (Fig. 6) was more rapid than in that of other reproductive individuals in which the nutritive tentacles did not develop. In other instances the reproductive heads may have lost the power of developing the long tentacles when the stolons were late in appearing. A clearing up of this point might throw light on the experiment described above (Fig. 4), in which a piece of a reproductive stalk grafted to a nutritive polyp regenerated a nutritive head. The reproductive head had not been removed until the day following the graft, and the stolons developed at the same time that the head was regenerated. The regeneration of the nutritive head might have been influenced by the developing stolons.

It gives me pleasure to acknowledge my indebtedness to Prof. T. H. Morgan for many suggestions during the course of this work.

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ON THE STANDING OF PTEROPUS HALDEMANI HALOWELL.

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In 1846 Halowell described a species of Pteropus from West Africa as *P. haldemani* (*Proc. Acad. Nat. Sci. Phila.*, Vol. III, p. 52); this species has generally been overlooked. Several years ago Mr. Paul Matschie of the Berlin Museum für Naturkunde resurrected the species (*Sitzungs-Bericht der Gesellschaft naturforschender Freunde zu Berlin*, 1899, Nr. 2, p. 30) and made the rather startling assertion that it was based on a young example of *Hypsignathus monstrosus* H. Allen (*Proc. Acad. Nat. Sci. Phila.*, 1861, p. 156). In his recent monographic work (*Die Megachiroptera des Berliner Museum für Naturkunde*, p. 42) Mr. Matschie repeats his previous views. As Mr. Matschie did not examine the types of either *P. haldemani* or *H. monstrosus*, his conclusions were formed entirely from a description which gave no idea of the cranial or palatal characters.

The types of both species are contained in the collection of the Academy of Natural Sciences of Philadelphia, and on examination the writer finds that Mr. Matschie's conclusions are not sustained by the specimens.

The type of *Pteropus haldemani* consists of an alcoholic skin from which the skull had never been detached, and on removal the latter is found to be quite typical of the genus Epomophorus, and in no way closely related to Hypsignathus. The molars are low and slightly grooved as in Epomophorus and lack the lateral cusps characteristic of Hypsignathus. The skull and the external aspect of the head exhibit no trace of the extraordinary club-like development observed in the last-mentioned genus, which would surely be appreciable even in a young individual.

The structure of the palate agrees exactly with *Epomophorus gambianus* Ogilby (*Proc. Zoöl. Soc. London*, 1835, p. 100) as

figured by Dobson (*Catalogue Chiropt. Brit. Mus.*, Plate II, Fig. 3, *a*), and *Pteropus haldemani* can, without hesitancy, be considered synonymous with Ogilby's species.

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THE COLORS OF NORTHERN POLYPETALOUS FLOWERS.[1]

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ACCORDING to the later systems of classification the Apetalæ and Polypetalæ form a single subclass, the Choripetalæ. In the apetalous families of eastern North America, which have been considered in an earlier paper, there are 175 green, 89 white, 51 yellow, 45 red, and 24 purple flowers. The 1217 polypetalous plants have 140 green, 410 white, 333 yellow, 84 red, 193 purple, and 57 blue flowers. The northern Choripetalæ, then, contain 315 green, 499 white, 384 yellow, 129 red, 217 purple, and 57 blue flowers. Of the 92 families belonging to the Choripetalæ, 47 contain green, 52 white, 45 yellow, 28 red, 30 purple, and 5 blue flowers. The much greater abundance of species and families with green, white, and yellow coloration, as well as the less specialized structure of the flowers, points to these colors as more primitive or more easily developed than red, bright purple, or blue. In certain genera, however, small dull red and purplish flowers are evidently derived directly from the primitive green.

The order Ranales includes the Nymphæaceæ, Magnoliaceæ, Ranunculaceæ, and six other families of less importance. The simpler species of this order have the organs of the flowers spirally arranged, separate and distinct, and the stamens and pistils indefinite in number, as in Ranunculus. From the dominating character of the Ranales, says Engler, it is clear that the other orders of this series diverge from the Ranales in various ways, some following one direction of development, some another. The ancestral form of the angiospermous flower would appear to have been a branch, or part of a branch, with carpophylls at the end, followed by androphylls, and then by the primitive

[1] The Colors of Northern Monocotyledonous Flowers, *Amer. Nat.*, vol. xxxiii, p. 493; The Colors of Northern Apetalous Flowers, *Amer. Nat.*, vol. xxxv, p. 197.

leaves destined to form petals, sepals, and bracts. No such inflorescence now exists, but an approach to it may be found in the Magnoliaceæ. In Magnolia the floral bud terminates the secondary branches, of which it is only a prolongation. The oblong flower of the Magnolia has the receptacle prolonged and the parts of the perianth, the stamens, and the pistils, spirally arranged and indefinite in number. In the arrangement of the plant families in a lineal series, those flowers which have the organs separate and which resemble most closely the proangiospermous floral branch are regarded as the simplest; while the highest rank is assigned to those which have the organs modified and consolidated, as in the Orchidaceæ and Compositæ.

In the Nymphæaceæ, or water lilies, we meet with dicotyledonous plants resembling monocotyledons in the structure of the leaf and rootstock. The analogous arrangement of the fibrovascular bundles in a Nymphæa and a Tradescantia has been excellently figured by De Bary. The successive steps in which simple and distinct carpels may become compounded are also well shown by the genera of this family. In the primitive genus Nelumbium, also in the oldest forms found in a fossil condition, the simple carpels are contained in little pits in the large fleshy receptacle; in Cabomba and Brasenia the oblong carpels are borne on the receptacle, but are separate; in the fossil genus Anœctomeria of the Middle Tertiary the carpels are partially united; in Nymphæa the union is complete; and finally, the culmination is reached in *Victoria regia*, where the compound ovary is inferior. Of the eleven northern species four are white, five yellow, one red, and one purple. Yellow coloring was probably very early developed, as it is the color of the primitive *Nelumbo lutea* and of the three native species of Nymphæa (Nuphar). Throughout the summer the numerous broad shining leaves and large yellow flowers of *Nymphæa advena*, the large yellow pond lily, form a well-known characteristic in the vegetation of ponds and slowly moving streams. The six sepals are unequal: the three inner are large and bright yellow; the three outer and smaller are wholly or partially green exteriorly, though the upper half is often yellow, while the interior lower portion is reddish purple. The numerous petals are thick, short,

truncate, wedge-shaped bodies, which serve as honey glands. The honey is freely secreted on the outer side near the top, the nectariferous portion being orange yellow. The fruit is scarlet. I have collected upon the flowers in Maine four Diptera, two Coleoptera, and one small bee, *Halictus nelumbonis*, which confines its visits to this flower. Great numbers of the small fly *Hilara atra* revel in the pollen. The single species of Cabomba is white with a yellow base, and the northern species of Castalia (pond lily) are pure white tinged with pink, or deep pink in a variety growing in eastern Massachusetts. In the famous *Victoria regia* of the Amazon the outer petals are white and the inner crimson, and in *Nymphæa cærulea* of the Nile the flowers are blue. The leaves of several genera are strikingly bicolored, being light green above and violet or reddish purple below. According to Kerner the anthocyanin, or purple coloring matter on the lower side of the leaf, can arrest the rays of light (which would otherwise escape into the water) and change them into heat and make them useful to the plant.

The largest tree flowers known belong to Magnolia. "Their effect in early spring is grand beyond description, illuminating the whole landscape and filling the air with their rich perfume." The red flower of *M. campbellii* of Himalaya is ten to eleven inches broad, while *M. macrophylla* of the Southern States has flowers ten inches in diameter. Of the five species of the Magnolia four are white and one greenish yellow. *M. macrophylla* is white with a purple center, while *Liriodendron tulipifera*, tulip tree, is greenish yellow without and yellow within. *Magnolia grandiflora* is fertilized by rose beetles or Cetoniæ. At night the white flowers are 5° to 10° C. above the surrounding air, and thus afford warmth as well as food.

Both the Nymphæaceæ and Magnoliaceæ produce very large and conspicuous flowers, which are pollinated by the smaller bees, flies, and beetles. While these splendid showy flowers are, no doubt, of benefit for attracting the attention of insects, yet it is evident that they could be produced only by large trees and vigorous herbaceous plants. The water lilies grow in situations where the soil is charged with nitrogenous matter, and the framework of the plant requires a minimum of mechanical

support. The Magnolias are stately trees, growing in rich woodlands. Both families have very large leaves. The primitive color of the flowers was probably green, as it still is in *Magnolia acuminata*. Transition stages from green to yellow occur both in Liriodendron and in *Nymphæa advena*. In other instances, as in certain species of Magnolia and Castalia, they became white at a very early stage, and in certain species subsequently changed to red. In the case of *M. macrophylla*, where the white flower has a large purple center, the entire flower may have been purple, as in *Illicium floridanum*, or anise tree, or it may be a deposit of pigment resembling that found on the inner side of the sepals of *Nymphæa advena*.

In a part of the species of the Ranunculaceæ the petals are wanting; in a part they are small and transformed into hollow nectaries; while in others they are regular and conspicuous. The ancestral stock from which the various genera have diverged doubtless possessed petals, or phyllomes, corresponding to this whorl; but they had already been lost by some generic lines when insects began to visit the flowers. Of the ninety-seven species, six are green, twenty-six are white, thirty-eight are yellow, three are red, thirteen are purple, and eleven are blue. Conspicuousness is insured by the sepals in Clematis and Caltha; by the petals in Ranunculus; by both the petals and sepals in Aquilegia; and by the numerous stamens in Thalictrum, Actæa, and Cimicifuga. In Thalictrum the white or lilac filaments are broad and petaloid. The flowers are visited infrequently by flies and the short-tongued bees.

Of the apetalous flowers, *Caltha palustris* and *C. flabellifolia* have a yellow, and the aquatic *C. natans* a white, calyx. A change of locality may induce a change from yellow to white, as *Anemone alpina* on the Central Alps bears chiefly sulphur-yellow flowers, but in the eastern limestone Alps its flowers are always white. In our native species of Anemone the sepals are green, white, or purplish, but florists offer scarlet and blue varieties. The anthocyanin displayed by the underside of the sepals of *A. nemorosa*, especially in bud, probably serves to convert light rays into heat; this plant blooms in early springtime. The sepals of *Clematis ochroleuca* are green, of *C. virginiana*

white or greenish white; but in most species of Clematis the color is purple. By hybridization a great variety of hues have been produced, including blue, red, cream, and yellow. The calyx of Hepatica is white, rose, or blue. Kerner remarks that the flowers, which appear as soon as the snow leaves the ground in open woods, by their blue color present a strong contrast against the yellow-brown leafage, whereas in green meadows they would scarcely be seen. The occurrence of blue sepals is rare and is perhaps nowhere so well shown as in this family. From this brief survey of the coloring of the calyx it is evident that its capability for developing a wide range of colors equals that of the corolla. Though commonly green and only protective, it may give rise to any color.

In other genera of the Ranunculaceæ the petals are present but are transformed into nectaries. In Eranthis and Helleborus they take the form of a trumpet; in Isopyrum they are spoon-shaped, in Nigella lamp-shaped; in Coptis they resemble a hood, in Aquilegia a horn of plenty; and in Delphinium the two upper sepals and petals are both spurred. Tubular petals have also been observed in *Ranunculus repens* by Masters.[1] This tendency is inherent in the flowers and not induced by the agency of insects, and has greatly aided in the production of the different genera. The sepals of all these flowers are conspicuous. In *Helleborus viridis* the calyx is yellowish green, and in *H. niger*, or Christmas rose, which blooms in winter, the flowers are at first white, turning pinkish, and then green. *Trollius laxus*, which grows in the shade of dense swamps, has greenish-yellow flowers, while *T. europæus* has bright yellow sepals. *Coptis trifolia*, a woodland plant, has small white flowers in springtime.

The species formerly included in the genus Ranunculus, but now segregated into several genera, have the petals large and regular. The nectar is secreted in a little pit near the base. The thirty-one species of Ranunculus native in the northern states are yellow, or whitish in *R. nivalis*, or occasionally in *R. acris* in autumn. A wide range of colors is displayed by *R. asiaticus*, including yellow, red, purple, and nearly black.

[1] *Vegetable Teratology*, p. 23.

R. viridiflora is green, with scarlet edges. In *R. auricomus* the petals are sometimes wanting, and their place is taken by the sepals with their bright yellow limb. In *Ficaria ficaria* (*R. ficaria*) the petals are yellow, or red fading whitish. The white flowers of Batrachium, or water crowfoot, show that they are descended from ancestral yellow forms by retaining vestiges of this color as honey guides at the base of the petals. The cultivated *Adonis annua*, or pheasant's eye, has showy orange or red flowers, to which the black anthers offer a marked contrast. The most highly specialized regular flowers of this family belong to Aquilegia, or columbine. They may be regarded as the culmination of the buttercup type. The sepals are regular and petaloid, while the petals are prolonged backward into a hollow spur. The intermediate stages between the nectariferous pit of the buttercup and the hollow petal of Aquilegia are excellently shown in the extremely variable petals of *R. auricomus*. *Aquilegia canadensis* produces scarlet flowers, which are yellow inside and rarely all over, or occasionally they are white. There are two other species in the northern flora which exhibit a similar coloring, *Lonicera sempervirens* and *Spigelia marylandica*, and the former is sometimes yellow throughout. *A. canadensis* is visited by bumblebees and humming birds. The European *A. vulgaris* is blue, purple, or white.

The two zygomorphic genera, Delphinium and Aconitum, are the most recent in their origin, and represent the highest stage of development attained by the Ranunculaceæ. The sepals are petal-like. The flowers are blue or revert to white, or, in *Aconitum reclinatum*, are regularly white. High specialization, pollination by bees, and probably blue color, are here correlated. Masters gives an instance in *Delphinium peregrinum* of perfectly regular flowers having five sepals and five oblong stalked petals, and also in Aquilegia the tubular petals may be replaced by flat ones.

At the period when insects began to visit the flowers of the Ranunculaceæ, the different genera were in a transition state and only partially differentiated. It is evident that one effect of their visits was to render the flowers conspicuous. This result has been reached in different ways in the various genera, according

as the pigments have been deposited in the sepals, petals, or stamens. But while insects have been instrumental in developing bright coloration, the particular colors of the different species have been very largely determined by other conditions. The yellow of *Caltha palustris* and Ranunculus has probably been preceded by no other color than green. These flowers are visited by numerous flies, beetles, and the less specialized bees. Syrphidæ are abundant, a family of flies with many species, characterized by yellow markings, which would indicate that yellow was especially attractive to them. Müller states that he has seen *Eristalis intricarius* hover over the yellow flowers of Caltha, as the males hover over the females, then suddenly settle to suck honey or feed on the pollen. He also suggests that their love of yellow may have arisen from their visiting flowers of this color, and that sexual selection may have been guided by this taste. The white flowers of Batrachium have evidently passed through a yellow stage, but in other genera white or purple has been developed directly from the primitive green, as in Clematis. The blue flowers of Hepatica, Aquilegia, Delphinium, and Aconitum, which are very attractive to bees, appear to have passed through a yellow or white stage. The organs of the flowers of the Ranunculaceæ, according to Masters, more frequently revert to leaves than do those of any other family except the Rosaceæ.

The Berberidaceæ, Menispermaceæ, Calycanthaceæ, and Lauraceæ contain but few species. The shrubs of Berberis, or barberry, have the wood as well as the calyx and corolla yellow. The flowers are attractive to bees and flies. The foliage in autumn is yellow and crimson. The three white-flowered species of the Berberidaceæ occur in woodlands and bloom in May. The Menispermaceæ are woodland vines with small white flowers in panicles, or green in Calycocarpum, where the petals are wanting. The small flowers of the Lauraceæ are apetalous, but the calyx is yellow. The species are aromatic shrubs and trees.

The original color of the Papaveraceæ, or poppy family, was probably yellow. The sap also of many genera is yellow or red. The beautiful flowers of Papaver are yellow or scarlet, with a darker center. If the flowers contained nectar, this central

marking would be regarded as a honey guide, but as they are nectarless, and are visited by Andrenidæ and Diptera for pollen, it must have a different significance. It may be due to the more abundant nutrition received by the central portion. In the cultivated variety called Shirley the edges of the flower are white and the center is crimson. If a plant receive a check during growth by transplanting, the flower may revert to pure white. Such color contrasts, however, render the flowers more conspicuous. According to Kerner, honeybees do not visit scarlet flowers, either because they do not distinguish this color, or because it is unpleasant to them. In a garden in front of the house where he lived the scarlet geranium, *Pelargonium zonale*, and the narrow-leaved willow-herb, *Epilobium angustifolium*, were in bloom at the same time and not far apart. He observed that butterflies visited both indiscriminately; but the honeybee never paused in its flight over the scarlet flowers, though it frequently sought the red-purple flowers of the willow-herb. The flowers of Papaver are one to three inches broad, and hybrids are sometimes twelve inches in width. The flowers of Argemone, or prickly poppy, are also several inches in width. *A. mexicana* is yellow, rarely white, and *A. alba* is regularly white. *Sanguinea canadensis*, bloodroot, has a white flower and red sap; but the flower is sometimes pinkish, as is indicated by the name "red Indian paint." The genera Stylophorum, Glaucium, and Chelidonium have yellow sap and yellow flowers.

A group of irregular flowers formerly placed in a separate family, the Fumariaceæ, are now included in the poppy family. The species are fertilized by the long-tongued bees and flies. The heart-shaped pendulous flowers of Bicuculla (Dicentra), Dutchman's breeches, are white or pink. The smaller flowers of Capnoides (Corydalis) are pale yellow, while the larger are bright yellow. *C. sempervirens* is pink with yellow tips, and in bud is greenish white, while the European *C. solida* has the entire flower red. The influence exerted by insects upon the particular colors is very uncertain.

The Cruciferæ, like the Umbelliferæ, form a very natural family; the flowers closely resemble each other and differ chiefly, as Müller states, in the number and position of the honey glands

and in the situation of the anthers in relation to these and to the stigma. Many genera show evidences of retrogression in the small white flowers and in the regularity with which self-fertilization occurs. *Pringlea antiscorbutica*, which grows on the stormy shores of Kerguelen Land, where no winged insects can exist, since they would be swept into the sea, has reverted to wind-fertilization. In sheltered places the petals, which usually are wanting, are frequently present, and "on the same raceme some flowers may possess only a single petal, others two, three, or four; and the petals, though usually of a pale greenish color, are occasionally adorned with purple." This family is much less attractive to insects than the Umbelliferæ, and is visited chiefly by flies and the less specialized bees, such as Andrena and Halictus, and by a few beetles and Lepidoptera. Some flowers have no recorded visitors.

Of the 113 flowers, 2 are green, 54 white, 46 yellow, 1 red, and 10 purple; 20 of the 37 genera contain white and 16 yellow flowers, but only 4 genera contain both yellow and white. The white flowers are usually small, or even minute, and self-fertilized as in Subularia (awlwort), Lepidium (cress), and Bursa (shepherd's purse). The yellow flowers are larger, as in Sinapis and Brassica, and frequently show a tendency to change to white. In Rhaphanus (radish) the wild species, *R. raphanistrum*, is yellow, changing to white; while the garden radish, *R. sativus*, is white or pink. In Roripa (nasturtium) the two aquatic species are white, as well as the horse-radish, which grows wild along streams; the other species are yellow. In Draba four of the species are yellow and seven white, and *D. nemorosa* is yellow fading to whitish. In other species the calyx changes from green to yellow. It would seem probable that in these genera the white-flowered species have been derived from yellow progenitors; yellow appears to have been very early developed, and was not improbably the original color of this family.

The white flowers very frequently show a tendency to turn pink or purplish, and three genera contain both purple and white flowers. *Malcolmia maritima* has pink-red flowers, changing to violet purple. This transition is beautifully illustrated by the

rhizome of *Dentaria bulbifera*, which when taken from the earth is as white as ivory, but, if placed in a glass of water and exposed to the light of the sun, in a few days turns to a deep violet. The cultivated varieties of the genus Mathiola (stock, or gilly-flower), from Europe, present a wide range of colors, — as white, yellow, red, violet, and blue. The colors of Iberis (candytuft) are white, red, and purple; and the marginal flowers of this genus and of Alyssum and Dentaria have the outer petals enlarged, as occurs in the Umbelliferæ. *Hesperis tristis* has dark-colored flowers, visited at night by insects, which are attracted by the scent.

The inflorescence is in umbel-like racemes, which in fruit become greatly elongated. The central green buds and the surrounding flowers form a nearly flat surface and present a variety of color contrasts. Kerner has described several different classes. In *Draba verna* and *Thlaspi rotundatum* the green buds in the center are surrounded by two colored rings, — an inner one of small white flowers and an outer one of brown or purplish fruits, to which the petals, now enlarged to twice their original size, closely adhere. A variegated effect is thus produced. In *Thlaspi alliaceum* and *T. arvense* the flowers of the inner ring are white, but in the outer ring the green sepals have changed to yellow, while the fruit remains green. In a third group the inner ring is composed of flowers with colored petals, which in the outer ring have faded to white. In *Draba aizoides* there is a change from yellow to white, and in *Arabis cærulea* from blue to white. A fourth group is represented by *Æthionema grandiflorum*, in which the upper and under sides of the petals are differently colored. The flowers of the inner ring present the white upper side of the petals, but in the outer ring the petals have changed their position so that the red underside is now visible.

While the flowers of the Cruciferæ show that conspicuousness is correlated with the visits of insects, they furnish little evidence that particular colors have been evolved by the selective tastes of special insect groups. Both yellow and white flowers are visited by Syrphidæ, and they are also very frequent visitors to the inconspicuous but scented flowers of *Lepidium sativum*.

The blue flowers of *Arabis cærulea* are likewise sought by flies, while the nocturnal flowers of *Hesperis tristis* are dark-colored and dependent upon their fragrance. The parti-colored appearance of the flower clusters and the changes of color of individual flowers would indicate that the guests were a miscellaneous-group of insects, with the color sense but feebly developed. How comparatively unimportant the color of a flower may become is well illustrated by *Lepidium sativum.* The small white flowers can be seen only a short distance, and in rainy weather do not expand. Yet they possess a strong scent, and Müller found them visited more frequently by insects than any other crucifer. Throughout the species of this family the petals have not been extensively modified either in form or color.

The flowers of the Capparidaceæ resemble those of the Cruciferæ both in form and color. *Polanisia graveolens* (clammy weed) has purplish sepals and stamens, and whitish petals.

There are three species of mignonette (Resedaceæ) in the northern states. The flowers are especially attractive to small bees of the genus Prosopis. These bees, which have an aromatic odor, are coal black, marked with yellow. They are doubtless attracted by the sweet fragrance, which can be perceived at a long distance. *Reseda luteola* (yellow weed) has greenish-yellow flowers and is cultivated for its yellow dye. *R. alba* has white flowers. In *R. odorata* the receptacle is at first yellow, changing to orange red; the petals are white or red, and the anthers red. The perfume is intense. On flowers growing in his window Müller collected five species of Prosopis, besides other insects. The strong scent of these flowers probably compensates for their small size and greenish colors.

The Sarraceniales contain two remarkable carnivorous families, the Sarraceniaceæ, or pitcher-plants, and the Droseraceæ, or sundews. The leaves, which are adapted to trap insects, are more conspicuous than the flowers. *Sarracenia purpurea* has purple-veined leaves and large purple flowers, while *S. flava* has green leaves and yellow flowers. The walls of the orifice, and the hoods, or lids, of the pitchers are the most highly colored parts. Leaves without ascidia or pitchers are green. The upper part of the pitcher of *S. laciniata* is pure white, marked

with a network of dark red veins. Of the five northern species of Drosera, four have white and one purple flowers. The red glandular leaves are far more prominent than the flowers. In the common *D. rotundifolia* the small white flowers open at midday, one or two at a time, and are visited sparingly by flies.

The order Rosales includes some thirteen families, differing but little from each other. The Saxifragaceæ, according to Engler, form the center of development, while the Rosaceæ and Papilionaceæ are regarded as sister families. The primitive character of many of the genera appears in the indefinite number of the stamens and pistils and their separate insertion upon the receptacle. The order, however, exhibits an advance upon the Ranales in that the carpels are more often united and the ovary inferior.

Of the Crassulaceæ, or orpine family, two species are green, two white, five yellow, two red, and two purple. The two green-flowered species have small flowers and grow in wet places, and in the case of *Penthorum sedoides* (ditch stonecrop) the petals usually are wanting. The genus Sedum (stonecrop) contains white, yellow, red, and purple flowers, with the honey readily accessible to short-lipped insects. In *S. acre* the leaves are yellowish green and the flowers yellow. While the blossoms are small they are produced in such profusion that they completely cover the plants, which grow in dense tufts and are sometimes called "golden moss." In *S. telephium* the petals are purple and often the entire plant. The honey is more deeply concealed than in the preceding species, and the flowers are in broad cymes, which are conspicuous and facilitate insect visits. In the species of Sempervivum the honey is still more deeply hidden antl can be reached only by long-tongued insects. The cymose flowers are showy pink or purple. The petals of *Sempervivum wulfenii* are sulphur yellow with a purple base, and are pollinated by bumblebees. This purple coloring Müller believed to be a remnant inherited from a purple-flowered ancestor, from which the sulphur-yellow form, which is unlike the primitive yellow form of Sedum, had been developed by the selective influence of bumblebees. This color change is not improbable, for the petals of *Arnebia cornuta*, when they expand, are marked with dark

purple spots, which on the third day fade entirely away, leaving the flowers bright yellow. The colors of the flowers of the Crassulaceæ are often correlated with the colors of the stems and leaves.

The flowers of the Saxifragaceæ are small and arranged in racemes, cymes, and panicles, or solitary in Parnassia. The honey in most species is easily accessible, and the visitors are chiefly flies, which appear to have influenced the development of the coloring. To these insects white and yellow, marked or dotted with yellow, red, or purple, are thought to be especially attractive. The relation of Diptera to the flowers of Saxifraga is shown in the accompanying table compiled from Müller and Knuth.

Species.	Color.	Diptera.	Hymenoptera.	Coleoptera.	Lepidoptera.	Total.
S. rotundifolia .	White	14	1	—	—	15
S. stellaris . . .	White	12	2	1	1	16
S. aspera	White	2	—	—	—	2
S. bryoides . . .	White	9	2	2	—	13
S. aizoön	White	65	11	5	10	91
S. cæsia	White	15	3	3	3	24
S. exarata	White	4	1	—	—	5
S. muscoides . .	Greenish yellow	6	1	1	1	9
S. aizoides	Golden yellow .	85	20	8	13	126
S. oppositifolia .	Purple	4	—	1	3	8
Total		216	41	21	31	309

The genus Saxifraga is highly interesting because of the colored dots upon the corolla of many of the species. The white corolla of *S. rotundifolia* is sprinkled with round dots, the outer

of which are intense purple red; the inner are yellow, and the anthers white. The snow-white petals of *S. stellaris* are beset with purple dots and adorned with two orange-yellow spots. *S. aspera* and *S. bryoides* are white, with numerous shining yellow dots. *S. aizoides* has large golden-yellow flowers, marked with numerous orange-red dots; the nectaries and anthers are also yellow. This is the most conspicuous species of the genus and attracts 126 insects. *S. oppositifolia* has the honey more deeply concealed and is carmine or purple, and is diligently visited by butterflies. *S. hirculus*, of Labrador, is bright yellow with scarlet spots. In *S. michauxii* the three largest white petals have a pair of yellow spots at the base, but the two smaller are unspotted. The petals of *S. geum* are white, with a yellow spot at the base and several smaller purplish spots in the middle. As evidence that these markings are pleasing to Diptera, Müller states that he saw many specimens of two drone flies, *Sphegina clunipes* and *Pelecocera scævoides*, before sucking honey or eating pollen, poising before the dotted flowers of *S. rotundifolia* as if delighted by their appearance.

In his *Alpenblumen* Müller has tabulated his observations upon the relations of Diptera to the different colors of flowers. Most anthophilous species and families of flies made a much larger number of visits to white and yellow than to red and blue flowers. The Bombylidæ, which are suctorial only, showed a preference for red and blue to white and yellow in the proportion of 75 to 25; and the genera Volucella and Rhingia, of the Syrphidæ, showed a similar inclination in the proportion of $77\frac{2}{10}$ to $22\frac{8}{10}$. The less specialized Diptera were by far the most common on white and yellow; but as the proboscis increased in length and the species confined themselves more strictly to flowers, the percentage of visits to red and blue flowers increased from $14\frac{1}{10}$ in the Muscidæ to $29\frac{3}{10}$ in the Syrphidæ, and to 75 in the Bombylidæ. The Syrphidæ as flower visitors surpass all other Diptera, both in numbers and importance. The percentage of visits to yellow and white was $69\frac{7}{10}$, and to red and blue flowers was $29\frac{3}{10}$. The species marked yellow, whether short or long tongued, were two to three times as abundant on white and yellow as upon red and blue flowers. None of the Tabanidæ,

which do not restrict themselves to flowers, were observed on red and blue blossoms. Due consideration should be given to the limitation of the visits of flies by the form of the corolla, by scent, by the acuteness of the species in finding the honey, as well as by its adaptations and habits, and to the fact that in the case of several families the above conclusions are based on comparatively few observations.

Chrysoplenium alternifolium has no petals, but the sepals are bright yellow and the disk is also yellowish. Like the species of Saxifraga, it is visited chiefly by flies. The petals of Parnassia are white, with greenish veins. *P. palustris* is described as a "deceptive flower." It contains numerous yellow glandular bodies which appear like minute drops of honey, by which flies, especially Syrphidæ, are deceived. The flower contains a small amount of honey. In Hydrangea the cyme is made conspicuous by the enlargement of the calyx of the marginal flowers. In *H. hortensia*, cultivated from eastern Asia, the flowers are nearly all neutral and enlarged, and at first are green, changing directly to pink or purple. "The variable character of Hydrangea flowers," says a writer in the *Journal of Horticulture*, "when the plant is grown under certain conditions, has for many years been a sort of horticultural puzzle, which is still far from being satisfactorily solved. Plants with bright pink flowers, and those with flowers of a tolerably good blue, are not infrequently met with in positions near each other and apparently in soils exactly alike." A change of color in the flowers from pink to blue is sometimes caused by a change of soil, as the removal of a plant from a peaty soil to one of opposite character. The addition of iron to the soil frequently appears to produce the desired color change, though time is always required, the blue coloring not developing until the second year. *Saxifraga pennsylvanica* and *Heuchera americana* have green petals. Several species of Saxifraga are proterogynous, and the flowers in passing from the female to the male stage increase greatly in size.

The Grossulariaceæ (gooseberry family) contain only a single genus, Ribes. Of the northern species four are green, six white, one yellow, and two greenish purple. Most of the species are greenish in part. In *Ribes alpinum* the female flowers are green

and the male greenish yellow and much more conspicuous, though of no larger size. By this device insects are induced to visit the male, or pollen-bearing flowers, first. The petals of *R. sanguineum* change from white to pink, and of *R. aureum* from yellow to carmine. This color change, says Müller, also occurs in several species of Fuchsia and Lantana and enables the more intelligent bees to economize time by determining instantly those flowers which no longer contain nectar.

There are four green, thirty-five white, thirty-nine yellow, thirteen red, and four purple flowers in the Rosaceæ. The green flowers are small and apetalous, as in Alchemilla; the white flowers are very generally tinged or tipped with red, and vary from small in Spiræa to large in Rubus. Of the twenty genera in the northern states, twelve contain white flowers. Of the four species in Spiræa, three are white and one, *S. tomentosa* (hardhack), is rose, or rarely white. The flowers contain nectar and attract numerous flies, beetles, and Hymenoptera. Beetles are very frequent visitors to the small white flowers of *Aruncus aruncus*. The genus Rubus contains seventeen species, all of which are white except the purple *R. odoratus* and the pink *R. arcticus*. *R. strigosus*, or the wild red raspberry, has small, erect white petals, and the visitors are much fewer than to the blackberry, *R. villosus*. Though the flowers of the blackberry are also white, their increased conspicuousness secures them a much larger company of visitors, which is not far from one hundred. The petals are broad and flat, and the panicles large and numerous. *Dalibarda repens*, a woodland plant, produces both cleistogamic and open white flowers which are seldom fertile. The common field strawberry blooms in May and June, when the white blossoms contrast with the green meadow, and the growing grasses are as yet too short to conceal them.

Of the twenty-four species of Potentilla, two, *P. arguta* and *P. tridentata*, are white and are probably derived from yellow-flowered ancestors. They both grow in dry, rocky places. The other twenty-two species are yellow and are visited by small bees and flies. The prevalence of yellow coloring in this primitive genus would indicate its early development in the rose family. Yellow is also the color of *Duchesnea indica* (Indian

strawberry), which is certainly closely allied to the line of the field strawberry. *Waldsteinia fragarioides*, or the barren strawberry, which in leaf habit has the aspect of Fragaria, is likewise yellow. The simpler species of avens are yellow or white, while those with the honey concealed are purple. In *Geum rivale* (purple avens) the petals are purplish orange and the calyx brown purple. The honey can be reached only by long-tongued bees and flies, such as Bombus and Rhyngia. In *Comarum palustre* (marsh cinquefoil) the petals are purple and the sepals also inside. The plant grows in swamps and is visited by flies and less frequently by bees. The primitive color of both these species seems to have been yellow. The purple-flowering raspberry, *Rubus odoratus*, is however derived from white-flowered progenitors, for in New York at Pine Hill, Ulster County, a white-flowered form occurs, and the white species of this genus are frequently reddish or purple.

The ten species of Rosa in the northern states are rose or pink, varying to white. Though the flowers contain no honey, their color and fragrance attract many insects to the ample store of pollen. Several species have odors so peculiar that they may be recognized by them alone. The theory of Delpino that the distribution of this genus was determined by the range of certain families of Coleoptera has been disproved by the observations of Müller and others who have found bees very frequently upon the flowers. Beetles may often be collected, some species of which devour the petals bodily. The flowers of *Rosa canina* gain increased conspicuousness by always turning towards the sun. In Germany they are visited by eight beetles, six bees, and two flies.

The family of the Rosaceæ is very prolific in hybrids, and more than two hundred have been observed in nature. Innumerable hybrids of Rosa have been produced under cultivation which display countless combinations of yellow, red, and white, — as white tinged with yellow or pink, yellow fading to white or shaded with rose, or pink changing to white, rose shaded with yellow, or intense coloring such as crimson, carmine, and scarlet. In one variety on the same root there are produced every intermediate shade between white and red, and in another the colors

vary from yellow to crimson. There is no blue rose, but a white variety of *Rosa rugosa* from Japan has a bluish tinge. Blue does not, indeed, occur in this family. While red is common, none of the Rosaceæ are adapted to Lepidoptera. The visitors are a miscellaneous company of flies, beetles, and Hymenoptera.

This family exhibits a marked tendency in stem, leaf, bud, flower, and fruit to develop reddish coloration, — a tendency which is probably due to the chemical constitution of the sap. The smaller and less specialized Rosaceæ are yellow and white, and are visited by a variety of short-lipped insects. The increase of the white flowers in size and conspicuousness is usually attended by red coloration. Owing to the chemical constitution of the nutritive fluid, probably to its acidity (for when the petals of a rose are treated with ammonia they become blue), there has been no opportunity for the development of blue coloration by insects. With the enlargement of the perianth and the increased flow of sap, red tints have tended to appear by process of oxidation. The correlation of red coloring with an increased flow of the sap is well illustrated by the galls of the wild rose tree, which are often "as rosy as the rosiest apple." An abnormal flow of sap is caused to the part stung by the insect, and red coloration is due to the action of light, for it is of no service to the plant. Again, when the flowers of *Cratægus coccinea* are stung by the gallfly the different organs all become red, and the change in coloring is accompanied by an increase in size. In some instances, according to Darwin, red colors indicate greater vigor on the part of the plant, and I have also observed that the dwarfing of red flowers under cultivation may cause them to revert to white.

There is nothing more beautiful in the vegetation of the temperate zone than an orchard laden with expanding blossoms. The great quantities of flowers form billowing banks of whiteness, tinged with rose and flecked with the vivid green of the unfolding leaf buds, from which exhales the well-known sweet fragrance of the apple blossom. Of the Pomaceæ, or apple family, twenty-seven species are white and five red or partially white. The flowers are regular and usually clustered. Species

of Sorbus (mountain ash) and Cratægus (thorn) are very attractive to beetles, though often visited by flies and bees. The pear and apple are sought by fewer beetles and depend chiefly upon Hymenoptera and Diptera. The native species of apple are rose or pink, but readily change to white. The so-called bloomless apple has small green petals resembling sepals.

Twenty species of the Drupaceæ, or plum family, are white, and one, the peach, is pink. The blossoms of many plums appear in early spring in advance of the leaves and often completely wreathe the limbs. The flowers are visited by a great number of Andrenidæ, and in less than two hours I collected one hundred and twenty specimens on a Japan plum, and these were but a small part of those present.

The Mimosaceæ, Cæsalpiniaceæ, Krameriaceæ, and Papilionaceæ are often united in one family called the Leguminosæ, because the simple pistil becomes in fruit a legume. The Mimosa family connects the rose family with the Papilionaceæ. It is confined chiefly to the tropics, where the species are very numerous. The flowers are small, perfect, and regular, with the stamens distinct as in the rose family, or monodelphous as in the Papilionaceæ. In the northern species the colors are white, yellow, or pink. The filaments are long and threadlike, and are more conspicuous than the petals.

The pea, bean, clovers, vetch, and a whole host of leguminous allies are grouped together in the Papilionaceæ, — a name derived from the fancied resemblance of the flowers to a butterfly. Occasionally perfectly regular flowers occur by reversion, as has been observed in Laburnum. For the most part, nine of the ten stamens unite to form a tube, at the bottom of which lies the honey, if present; four of the petals interlock around this tube, while the fifth, called the "standard," is broad and erect and bright colored to attract the attention of insects. The flowers are fertilized by bees, which rest upon the wing petals, bracing the head against the standard and bringing the ventral side of the body in contact with the stigma and pollen. The irregularity of the flowers is due to their horizontal position and the unequal strains to which the petals are subjected. In the case of certain species bees alone are able to depress the keel

and obtain the nectar, and in their absence the flowers fail to set seed. Slight imperfections frequently permit flies and butterflies to steal the honey without rendering any service in return; and it has been suggested that the numerous species may be due to the efforts of the plants, metaphorically speaking, to remedy these defects.

The inflorescence is mainly in heads and racemes, but the effect of the individual flower cluster is often magnified manifold by the massing of the plants. In worn-out fields the vetch, *Vicia cracca*, often takes entire possession of the soil, forming large patches of purple blue. Similar effects are attained by the clover and wild lupine. Of the 197 species in the northern states, 39 are white, 33 are yellow, 13 red, 88 purple, and 24 blue. The predominance of blue and blue purple are believed to be due to the preference of bees for this color. The well-known experiments of Lubbock have shown that the honeybee can distinguish between colors. Scarlet, fire red, and all lurid colors are avoided by the honeybee. Blue, violet, and red are most attractive, followed by various shades of purple, yellowish white, and white.

An examination of the genera in which more than two species occur shows that they are rarely monochromatic; one or more species are usually differently colored from the rest. In Baptisia three species are white, two yellow, and one blue; in Trifolium (clover), four species are white, three yellow, four red, and three purple; in Psoralea two species are white, six purple, and three blue; in Astragalus seven species are white, three yellow, twelve purple, and one blue; and in Meibonia (tick trefoil), two species are white, one red, and nineteen purple. It is probably more advantageous in these genera for a part of the species to be of one color and a part of another than for all to be blue. When species are closely allied bees tend to visit them indiscriminately, as may be observed in the buttercups and goldenrods. But even in these cases they exhibit a preference to keep to a single species and would be greatly aided by differences in the coloring.

Many of the flowers of the Papilionaceæ in fading undergo a change of position and color. In the white clover the white

central flowers contrast with an older outer ring of rose-colored flowers. In the yellow clover the newer flowers contrast with a ring of chestnut brown. In *Vicia cracca* the older flowers bend downward and turn from violet blue to dark purple; while the purple flowers of Desmodium become green in withering. Striking color contrasts are also presented by the individual flower. The wings of the white corolla of *Vicia faba* (bean) are marked with two black eye-spots, and in the sweet pea and cultivated lupines the combinations of color are innumerable. *Astragalus vesicarius* has yellow blossoms in the Tyrol but violet on the limestone mountains of Hungary.

Nine families belong to the order Geraniales. In the genus Geranium of the Geraniaceæ the larger and more conspicuous purple flowers are visited abundantly by insects and have nearly or quite lost the power of self-fertilization. The smaller flowers are paler or white, attract few insects, and self-fertilization regularly takes place. *Geranium pratense* has been seen to produce on the same plant, when cultivated in a garden, both white and blue flowers. *G. robertianum*,[1] or red robin, has ribbed red-purple petals and, notwithstanding its disagreeable odor, is sought by bees as well as flies and beetles. In the pink flowers of *Erodium cicutarium* the upper petals are marked with dark lines, which serve as pathfinders. According to a series of forms figured by Knuth these markings vary greatly, from a few lines to spots and markings on all five petals.[2] In the genus Pelargonium from the Cape of Good Hope, this office of the upper petals becomes very highly developed; *P. tricolor* has the three lower petals white and the two upper crimson, each with a dark spot at base. The flowers of the Geranium always turn towards the sun.

Most of the northern species of Oxalis of the Oxalidaceæ are yellow and possess an acid juice, but *O. acetosella*, which grows in open woodlands, has large, pretty white flowers, veined with pink. It is sometimes called "wood sour," as druggists obtain from it salt of lemons. The plant is of social habit, and the flowers are quite conspicuous, yet are rarely visited by flies,

[1] Darwin. *Animals and Plants under Domestication*, vol. i, p. 404.
[2] Knuth. *Handbuch der Blutenbiologie*, Bd. i, p. 118.

beetles, or bees. Cultivated species of Oxalis are red or rose. *O. flava* is yellow, edged with red; and *O. versicolor* is white above and red beneath, so that the blossoms are white in the sunshine, and red when rolled up in the shade.

Like the Papilionaceæ, the flowers of the Polygalaceæ stand horizontal, and the petals are more or less united into a tube with a carina and alæ. The largest-flowered species is the fringed Polygala, *P. paucifolia*, which in spring produces beautiful rose-purple crested blossoms, with an occasional white variety. It is attractive to butterflies as well as bees. On the Alps, Müller found one species of Polygala fertilized entirely by butterflies. Most of our species have very small flowers, which are either greenish purple, or yellow changing to green in drying.

In the capability of the leaves to develop bright colors, and in the minute and reduced flowers attractive to Diptera, the Euphorbiaceæ, or spurge family, resemble the Araceæ, though it has not the remarkable adaptations for fertilization of Arum. The spurge family is of immense size and of very wide geographical distribution. The flowers are minute and have undergone much reduction. They are usually apetalous, and the entire perianth may be wanting, as in Euphorbia, where a single stamen represents a flower, and the flower cluster with its colored involucre was mistaken by the older botanists for a single flower. The genus Euphorbia is attractive to flies, though also visited by beetles and Hymenoptera; and in response to their visits the inflorescence in certain species possesses bright colors, honey, and a honey-like scent. The colors of many northern species are green, but a part are white, yellow, rose, or red. On *E. cyparissas*, the common cypress spurge, naturalized from Europe, and which has escaped from cultivation, the bracts are yellow. In the Alps, Müller collected twenty-one flies, one beetle, four Hymenoptera, and three Lepidoptera on the flowers, and in middle Germany he found many more Coleoptera and Hymenoptera. The genera Ricinus and Croton are extensively cultivated for the tropical aspect of the magnificent foliage. *Ricinus communis* is anemophilous.

In the order Geraniales, to which the families just considered belong, and in the succeeding order, the Sapindales, the flowers

mark an advance upon the Rosales in that the cyclic arrangement prevails and there is an imperfect union of the carpels. The families of the Sapindales differ widely and have been divided into numerous subseries. The Empetraceæ, Buxaceæ, and Limnanthaceæ are represented in the northern states by only four species. The flowers are small, and probably partly primitive and partly reduced.

The Anacardiaceæ and a number of allied families are of much interest, as the inflorescence has been but little modified by insects. The species are mainly trees and shrubs with green, white, and greenish-yellow flowers, which are visited by Diptera and the smaller and less-specialized Hymenoptera. The Anacardiaceæ, or sumac family, have small, regular flowers in dense panicles. Both the sepals and petals are present, but the flowers are greenish or greenish yellow, though sometimes tinged with red as in the smoke tree. They secrete honey and are attractive to flies and Andrenidæ. On the smoke tree, *Cotinus cotinus* (*Rhus cotinus*), there have been collected six flies, one beetle, and ten Hymenoptera. The species tend to become diœcious, and *Cotinus cotinus* (*Rhus cotinus*) shows all transitional stages between staminate, hermaphrodite, and pistillate flowers. While the visits of insects have not developed bright colors, the leaves of *Rhus radicans* and the fruit of *R. aromatica* are red in autumn, and the wood of several species is orange yellow. *R. glabra* sometimes has the whole or a part of the flower cluster changed into small leaves.

The various species of Illicaceæ, or holly, have small white flowers, with freely exposed honey. The berries of *Ilex verticillata* are bright red, or rarely yellow, or even white. The visitors are similar to those of the preceding family. The Celastraceæ is composed of trees and shrubs with small, regular, green, yellow, and purple flowers.

Five species are green, three yellow, and one red in the Aceraceæ, or maple family. The green flowers of *Acer saccharinum* are without petals. In *A. rubrum* (red maple) the diœcious flowers are crimson, and the visitors are Andrenidæ and Diptera. There is no reason to suppose that the crimson coloring has been developed by insects, for the entire flower, the leaf

buds, the young leaves, and the twigs are of this color, while the bark yields a purple dye. The flowers appear in early spring before the leaves and were formerly anemophilous. *A. spicatum* blooms later, and the compound racemes of greenish-yellow flowers are large and erect. Müller states that dull-yellow flowers are avoided by beetles, but I have observed many beetles, as well as bees, upon the inflorescence of this species. Closely allied to the maple, but of more recent origin, is the genus Æsculus. The flowers seem to have possessed special capabilities that led to their adaptation to bumblebees. Among ornamental trees few present a more stately and splendid appearance when in blossom than the common horse-chestnut, *Æsculus hippocastanum.* It has large white flowers in crowded panicles, with the petals marked with yellow, which in a few days changes to orange and then to crimson. I have observed the honeybee, four species of Bombus, and one Andrena as visitors. Of the four other species of this genus three have yellow petals, and one, *Æsculus pavia,* bright-red flowers an inch in length.

Impatiens biflora, of the Balsaminaceæ, is orange yellow, spotted with reddish brown. One of the petals forms a spurred sac. August 10 I examined a large number of flowers; none of the spurs were perforated, and they were visited legitimately by *Bombus vagans,* which made from seven to twelve visits per minute. August 23 and 27 I found hundreds of the flowers perforated, and both honeybees and bumblebees stealing the nectar. If the Impatiens, fitly called "touch-me-not," could speak, what a protest it would utter! Various Diptera are attracted to the outside of the sac by the bright colors.

The colors of the Vitaceæ, or vine family, are green, closely resembling the foliage, and depend entirely upon their strong fragrance to attract insects. The inflorescence is in dense panicles. The calyx is minute, with the limb nearly obsolete. The green valvate petals form a hood over the stamens and never expand, but fall away by separating at the base and coiling spirally upward. The odor, which resembles that of mignonette, can be perceived at a long distance. "In a journey up the Danube," says Kerner, "through the part of the valley called the Wachan, with its vine-clad slopes, I found the air of the

whole valley, even that above the water, so filled with the scent of vine flowers that it seemed almost impossible they should be so far off. And yet the nearest vines on the banks were one hundred yards above the water and at least three hundred yards from the boat. Afterwards I found, when wandering through the vineyards, that the smell of the flowers close at hand was much weaker than at a distance, and was forced to the paradoxical opinion that with increasing distance and diffusion over a wider area the scent does not diminish but waxes stronger." Under cultivation the species are usually perfect, but when growing wild are mostly unisexual. Cross-fertilization, according to Knuth, is occasionally effected by the wind. As visitors to the flowers of *Vitis vinifera* there have been observed the honeybee, and various species of Halictus; while of Coleoptera, notwithstanding the green flowers, there have been enumerated twenty-one species. Müller's statement that "beetles are only or mainly attracted to flowers by bright colors" does not agree with the many species observed on the flowers of the vine.

Union of the carpels prevails in the order Malvales, which includes the two families Tiliaceæ and Malvaceæ. A part of the genera with the carpels distinct, or but slightly united, still preserves a more primitive stage in the evolution of the flower. As in the vine family, the flowers of the linden, or lime tree, depend on their strong scent, rather than upon their coloration, to attract pollinators. The greenish-white flowers of *Tilia americana* are in small, drooping, cymose clusters, sheltered beneath a floral bract. The thickened concave sepals secrete and contain the honey, which a pubescent fringe prevents from escaping. A high value is placed upon honey made from the linden; in some localities the leaves are also covered with a copious secretion of a sweet liquid, and sugar has been made from the sap. The strong scent, which is more noticeable at a short distance than close to the tree, is very attractive to the honeybee, many of which I have seen at work on the flowers in Maine. On *T. ulmifolia* in Germany Müller and Knuth collected eleven flies and seven bees. The absence of beetles I attribute not to the dull color of the petals, but to the inaccessibility of the drooping inflorescence, covered both by the leaves and the floral

bract. The leaves of a part of the species are bicolored, green above, and white, because densely woolly, beneath.

One-half, or thirteen, of the northern species of Malvaceæ are pink or red, four are red purple, five yellow, and four white. No other polypetalous family has so large a percentage of the flowers red. Both in temperate and tropical regions the blossoms are remarkably large and showy, and are usually yellow or red. The chief agents in intercrossing are bees. *Malva rotundifolia* has white flowers striped with pink, and slender pink stigmas, while *M. moschata* has either pink or white blossoms. The marsh mallow, *Althæa officinalis*, well known for the use of the mucilaginous root in confectionery, has pink flowers an inch broad; and *A. rosea*, the hollyhock of the garden, displays white, yellow, rose, crimson, purple, and black hues. A single species of Abutilon with yellow flowers has become naturalized from Asia. In South America the natural fertilizers of Abutilon are humming birds. The genus Hibiscus consists of splendid flowers of immense size. In color they are yellow, red, or white; the yellow forms have a purple or blackish eye, and the red a dark center. The common cotton, *Gossipium herbaceum*, one of the most valuable of nature's plant productions, has yellow petals, and the floral and extra-floral nectaries attract many insects as well as the ruby-throated humming bird.

Within the order Parietales the placentæ are parietal; "and the floral evolution," says Engler, "has already reached very complicated floral types." The Theaceæ (tea family) is mainly of tropical distribution, consisting of shrubs or trees with large solitary white flowers. Three species occur in the southern states. The handsome white flowers of *Stuartia malachodendron* have purple filaments; in *S. pentagyna* the petals are cream color and the sepals reddish outside. To this family belong the tea plant and the Camellia.

The Hypericaceæ have nearly monochromatic flowers, as twenty-two species are yellow and two red. The larger flowers of Hypericum are bright or orange yellow, as *H. ascyrum*, while the smaller are often pale yellow. The leaves, sepals, and petals of *H. maculatum* are sprinkled with numerous black dots. *H. perforatum*, introduced from Europe, contains no honey, but

the large, black-dotted, bright-yellow flowers attract many flies, which feed on the pollen. The smaller-flowered species are rarely sought by insects, and self-fertilization is possible throughout the genus. The two small, reddish-flowered species belong to the genus Triadenum. The petals of *Triadenum virginicum* are rose colored, with deeper veins, and do not exceed the calyx; the honey glands are orange and the anthers bright yellow with white filaments. The flowers are very sparingly visited by insects, and after repeatedly watching them I have observed only two bees and three flies. The stem, the capsule, and often the leaves are a deep crimson, as is often the case in Hypericum. The change in the petals from yellow to red is probably correlated with the red coloration of the plant rather than due to insect selection. In *Hypericum perforatum*, which frequently has the foliage crimson colored, the yellow petals are tinged with rose in the bud, which fades away as the flower opens. In *Epilobium palustre* reddish flowers are more common when the stems are red than when they are green.

In the Cistaceæ, or rock-rose family, the genus Helianthemum (frostweed) has large yellow flowers, which throughout the day follow the sun. They are ephemeral, but the plants remain in blossom for a long time, as there is a succession of flowers, as in the crucifers. There is no honey, but the pollen attracts a miscellaneous company of insects. As is frequently the case in pollen flowers, pollen falling from the anthers is not lost but lodges in the concave petals. The small greenish flowers of Lechea (pinweed) are self-fertilized.

The violet family in the northern states contains 7 white, 6 yellow, 4 purple, and 17 blue flowers. About 300 species of this family and 150 of the genus Viola have been described. Müller regards yellow as the original color of the violets. The small, short-spurred *V. biflora*, which in the Alps is fertilized by flies, has yellow flowers; the large-flowered *V. tricolor*, variety *alpestris*, presents all stages in the passage from yellow to blue. "Many plants have flowers which are yellow throughout; in others the flowers are yellow when they open but change gradually to blue; and in others the change to blue occurs immediately after opening, or even before." *V. calcarata*, which has a spur

from 13 to 25 mm. in length and is fertilized by Lepidoptera, chiefly by *Macroglossa stellatarum*, displays, according to Kerner, in the meadows of the western Alps a blue corolla, and a yellow corolla in the eastern Alps. Darwin transplanted a large, uniformly colored, dark-purple variety of the pansy while in full flower, and it subsequently produced smaller flowers, with the lower petals yellow. The white forms appear to be derived from blue progenitors, for the former are purple veined and may be tinged with violet. Blue species of Viola which often have white flowers are *V. palmata*, *V. obliqua*, and *V. odorata*, and in various stages *V. canadensis*. Pathfinders among white northern polypetalous flowers are of infrequent occurrence. The most prominent instances are *Saxifraga michauxii*, with three of the unequal white petals marked with yellow; *Oxalis acetosella*, white with reddish veins; Parnassia, with greenish veins; *Magnolia macrophylla*, *Æsculus hippocastanum*, *Lespedeza hirta*, and *L. capitata* display purple spots. In the white violets the purple honey guides are highly developed, which may be best explained by supposing them descended from blue-flowered ancestors with darker veins similar to existing species.

The beautiful and richly variegated varieties of *V. tricolor*, the garden pansy, are due partly to selection and partly to hybridization. The corolla may be pure white, yellow, red, blue, purple, or black; or there may be combinations of yellow and blue; yellow and red; yellow, blue, and white; and blue and white. According to Strasburger, in the pansy the cells of the epidermis of the petals contain both violet sap and yellow granules. "The striking diversities in color presented by different parts of a given petal depend wholly upon combinations of these two elements of color, — namely, violet sap and yellow granules."[1] Places which are devoid of both these elements are white, as the light is refracted and reflected by the intercellular spaces containing air. When sections of white roots of a violet plant are exposed to the air they change to violet; and the leaves of *V. cucullata* when grown at alpine altitudes become yellow.

While the violets vie with the roses in popular favor, they do not prove attractive in an equal degree to insects. In Maine I

[1] Goodale. *Physiological Botany*, p. 170.

have rarely observed visitors to the white and blue varieties, but on the yellow *V. rotundifolia*, which blooms early in May, I have seen many bees belonging to the genera Bombus, Nomada, and Andrena. Besides the conspicuous flowers, which are often unfruitful, many species produce cleistogamic flowers, in which the petals are reduced to mere scales, but the green sepals remain essentially unchanged. Occasionally the violets bloom a second time in late fall.

The failure of the yellow plastids to develop and the predominance of the colored cell sap produce blue flowers, and the non-development of both color elements results in white blossoms. In these color changes other ecological factors are more important than insects. For instance, of the yellow-flowered species one is visited by flies, another by bees, and the either yellow or blue *V. calcarata* is adapted to Lepidoptera.

The passion flowers are mostly natives of South America and are fertilized by humming birds and bumblebees. The calyx of the common *Passiflora cærulea* remains green until it has attained nearly its full size, when it changes to blue and white; the petals are white; the outer corona consists of several rows of blue filaments banded with white, but the inner corona is smaller and unmarked. Fritz Müller considered the coronæ to be of service in detaining small insects and keeping them caged for humming birds.

The Cacti, of which over a thousand species are natives of America, are especially abundant on the sandy plains of Mexico. The nearest living representative of the ancestral stock of this family is the genus Pereskia, which still possesses leaves of the usual form. "The earliest derived line was Opuntia. From the primitive Opuntia forms the columnar Cereus line was derived, with its numerous generic branches and diverse habits. Low down upon the columnar Cereus line the Echinocactus line branched out, which gave rise later to Mamillaria and still later to Anhalonia" (*Botanical Gazette*, Vol. XXVII, No. 3, p. 228). The flowers of the Cacti are solitary and sessile, with the sepals and petals and stamens numerous and spirally arranged. In size they are usually large and showy, as in *Cereus grandiflora*, queen of the night, where they are 20 cm. in diameter. In Pereskia

the flowers are white or yellowish; in Opuntia yellow, or in *O. opuntia* and *O. humifusa* yellow with a reddish center; in Cereus in the nocturnal forms white, in the diurnal species red or crimson; in Echinocactus yellow, white, and crimson; in Mamillaria yellow, pink, white, and purple; and in Anhalonia white, rose, and purple. The spines of the Cacti are often very beautiful objects and exhibit a great variety of color, as white, black, yellow, red, and purple. The stems, while usually green, are frequently nearly blue; the fruits are green, red, and purple.

The Thymeleaceæ and Eleagnaceæ in the northern states have no petals, but the calyx is enlarged, prolonged into a tube, and colored yellow, red purple, or white. In Europe *Daphne mezereum* has the red-purple flowers visited by long-tongued bees, flies, and butterflies; in the Alps the white or red flowers of *D. striata* are strong scented in the evening and are visited by moths.

The petals are wanting in the single green species of the Lythraceæ, or loosestrife family, *Didiplis diandra*, which has minute solitary flowers. The loss of the corolla is doubtless due to retrogression. In Ammannia the flowers are small and the purple petals fall away as soon as they expand, and in the southern *A. latifolia* they are wanting. The purple flowers of Lythrum vary from small to large. The eighteen possible ways of fertilization in the red-purple trimorphous flowers of *Lythrum salicaria* were made the subject of a long series of laborious experiments by Darwin, which resulted in breaking down the last barrier between species and varieties. It is a singular fact that the pollen of the longest stamens in this species is green, and of the middle-sized and shortest, yellow. The legitimate fertilizers are long-tongued insects. In Parsonia, or Cuphea as it is better known, the flowers are pink or crimson, and in a cultivated species from Mexico, *C. platycentra*, there are no petals, but the tubular calyx is bright vermilion with a violet border.

The Melastomaceæ are represented in North America only by the genus Rhexia, with handsome purple or yellow flowers. The family is most abundant in South America. In Heeria a part of the stamens are devoted to rendering the flowers conspicuous and a part to producing pollen. *Cyanophyllum*

metallicum, from Central America, has magnificent leaves, purple beneath and metallic blue above.

In the Onagraceæ, or evening primrose family, there are three green, fourteen white, twenty-four yellow, ten red, and six purple flowers. The three small green flowers belong to Ludwigia, and the petals are either minute or absent. Many of the white flowers show a tendency to change to pink or red. The large white flowers of the three northern species of Anogra all turn pink with age. Several species of Gaura also change to red. *G. coccinea* is red, turning scarlet in fading. The two species of Circæa (enchanter's nightshade) are delicate, colorless little plants, which grow in damp, shady woods and have small white flowers, fertilized by flies. The yellow flowers are in part diurnal and in part nocturnal as in *Onagra biennis*. Yellow is a much rarer color than white in flowers expanding at night.

With a single exception the flowers of Epilobium are red or red purple. *E. angustifolium*, called "fireweed" (as the plants spring up in abundance in newly cleared or burnt lands), has very conspicuous flowers in long, terminal racemes. The sepals and petals are purple red, except the lower sepal, which is white, and rarely the whole flower reverts to white. The pollen is greenish purple, and the stems and seed vessels are purple. Honey is secreted by a green, fleshy ring at the base of the style. Bumblebees are the most important agents in intercrossing and will visit as many as thirty-seven flowers in a minute. I have collected on this species twenty-one Hymenoptera, five Diptera, three Lepidoptera, and two beetles. In the smaller species of Epilobium, such as *E. palustre* and *E. lineare*, the small flowers are reddish or white, both kinds occurring on the same plant. When the stems are purple the flowers are more often red than when the stems are green. There are few visitors, and self-fertilization regularly occurs. The only northern white species of Epilobium is *E. alpinum*, which has small white flowers which are regularly self-fertilized. In *E. hirsutum* the four white stigma lobes form a cross on the red field of the petals.

The exotic genera deserve special mention. In *Lopezia racemosa*, from Mexico, there are on two of the petals dry,

shining, yellow bodies, which appear like drops of honey and are deceptive to flies, like the mock nectaries of Parnassia. The species of Fuchsia are confined chiefly to the shady forests of Central and South America. Both whorls of the perianth are highly colored, the calyx and stamens crimson or scarlet, and the petals purple or red. The flowers are pendulous and visited by humming birds. Crimson or scarlet flowers are not common where there are no humming birds. Kerner calls attention to the rarity of scarlet in south Europe compared with its frequent occurrence in tropical America, where in the primeval forests there are a great number of scarlet or fire-red species of Begonias, Fuchsias, Lobelias, Erythrinas, Salvias, and other crimson blossoms, which are surrounded by humming birds. Many hybrids of Fuchsia have arisen under cultivation. The earliest white-sepaled form was produced in England in 1822, while the first white corolla was secured in 1853.

In the Haloragidaceæ, or water-milfoil family, the petals are small or wanting and the flowers are wind-fertilized. The species are mainly aquatic.

The last of the polypetalous orders is the Umbellales, which includes the Araliaceæ, Umbelliferæ, and Cornaceæ. The flowers are small and densely aggregated in umbels, cymes, and panicles. In the ginseng family, or Araliaceæ, the flowers are white or greenish. In open, sunny thickets many plants of *Aralia hispida* grow together and produce numerous umbels of inconspicuous flowers with small white petals. The honey is abundant and freely exposed, and I have collected upon the flowers eighty-two visitors. Bees, with the exception of the honeybee, are not common; but the less specialized Hymenoptera, such as ichneumon flies and wasps, are numerous. Notwithstanding their want of bright colors, the flowers are very attractive to the butterfly *Argynnis aphrodite*, several of which may often be seen at work on the same plant. Though *A. racemosa* may be found growing but a short distance from *A. hispida*, its habitat is within the precincts of shady woods, where the greenish flowers attract a much smaller circle of guests. The green flowers of *A. nudicaulis* (wild sarsaparilla) are also visited by few insects. The color of *A. hispida* appears to be of slight

importance in attracting insects, compared with its sunny, sheltered location and easily accessible supply of honey.

Few plant families have attained a form of inflorescence so well adapted to insure cross-fertilization as the Umbelliferæ. To this family belong the caraway and carrot, the wild parsnip, the water hemlock, and parsley, — plants growing luxuriantly by the roadside, along the river, and in the meadow. There are about 1600 species, mostly confined to the temperate zone. The flowers differ very little in structure, and the species can be identified only by the mature fruit. The small flowers gain conspicuousness by aggregation, and by standing in the same horizontal plane afford a convenient landing place for insects, and admit of rapid fertilization. The honey is secreted in a thin layer by the fleshy disk surrounding the style. The number and variety of the visitors surpass those of all other families. In Germany there have been collected on the caraway 55, on the wild carrot 61, and on the wild parsnip 118 insects. Probably the number of visitors to many species exceeds 200; while there is thus ample provision for intercrossing, self-fertilization is in most species prevented by the anthers and stigmas maturing at different times. Admirable simplicity and perfection are here combined.

There are 58 white, 16 yellow, 1 purple, and 3 blue flowers. As in the Cruciferæ, which have also very uniform flowers, white and yellow predominate, red and purple are more rare. The 16 yellow flowers belong to 11 genera, only three of which contain more than one species. In his *Fertilization of Flowers* Müller enumerates 7 Diptera and 7 Hymenoptera collected on the dull-yellow flowers of *Pastinaca sativa;* 4 Diptera and 4 Hymenoptera on *Bupleurum falcatum;* 15 Diptera and 31 Hymenoptera on *Anethum graveolens;* and remarks, "So the dull-yellow flowers of this plant, *P. sativa*, like those of Bupleurum and Anethum, are visited only by Diptera and Hymenoptera, not by beetles." On page 574 he adds: "All dull-yellow, dirty-yellow, brownish-yellow, yellowish-white flowers, *Bupleurum anethum*, Pastinaca, *Rhus cotinus*, *Galium mollugo*, Ruta, Neottia, Euonymus, Euphorbia, Adoxa, Alchemilla, are entirely or almost entirely avoided by beetles. The only apparent

explanation of these facts is that beetles are only or mainly attracted to flowers by bright colors. If this explanation is correct, dull yellow must be an advantageous color for plants with freely exposed honey, protecting them from injurious guests." Subsequent observations of Müller himself showed that *Bupleurum falcatum* was very frequently visited by the beetle *Mordella pumila*. In Schlesien, Loew observed on *Anethum graveolens* 5 species of beetles; numerous beetles were observed in the Tyrol by Schultz on *Rhus cotinus*, and on Euonymus both Schultz and Knuth observed beetles. The writer has found beetles very frequent visitors to the dull-yellow flowers of *Acer spicatum*. These illustrations need not be carried further, as it is evident that more extended observations have disproved Müller's generalization that dull yellow excludes the visits of beetles.

In the Umbellales both yellow and white have probably been derived directly from the primitive green. The involucre of *Cornus canadensis* changes from green to white, and the petals of many species of Cornus are green in the bud but become white as the flowers expand, while in the Umbelliferæ greenish-yellow flowers occur. In Apium one of the species is greenish yellow and two others are white. In Sanicula, *S. gregaria* has yellow petals exceeding the calyx and bright-yellow anthers, and *S. marylandica* has very small greenish-white petals and anthers. In Peucedanum three species are yellow and one white. White flowers may in some instances have been derived from yellow, as it has been shown that the yellow petals change to white in individual flowers in the Cruciferæ. As regards attractiveness to insects the yellow flowers of the Umbelliferæ do not appear to possess any advantage over their white competitors.

In Thespium two of the species have yellow flowers, and in the third they are purple, with a common yellow variety. Many of the white species tend to become pink or reddish. In *Daucus carota* the central flower of the umbel, and frequently of the umbellets, is purple, and I have often seen the entire umbel pinkish. The coloration of this single flower can, of course, be of no advantage to the plant in attracting insects, and Darwin supposes that it is a relic of a former ancient condition. I am

inclined to believe that it is due rather to the chemical constitution of the soil and nutritive fluids and the action of light. The terminal flower receiving the greatest amount of sap would be the first affected, then those of the umbellets, and finally the entire umbel. The color changes of many flowers appear to be due to such causes rather than to the influence of insects. In Low Germany *Pimpinella magna* is white, and in the more intense light of the Alps pinkish. Both rose-colored and yellow flowers have been found on plants of *Eriogonum ovalifolium* growing in silver-ore localities. Chemical analysis showed that the rose flowers contained arsenic, which was not present in the yellow. As a stimulus in nutrition may intensify the color, so a check in growth may cause it to revert to white.

Increased conspicuousness of the umbel is gained in some genera by the enlargement of the outer petals of the marginal flowers, as in Heracleum. White bracts subtend the white flowers of Astrantia, and yellowish bracts the dull-yellow flowers of Bupleurum, and in Eryngium the flower stalk is colored.

The Cornaceæ include many ornamental shrubs valued for their bright-red bark, their variegated leaves, the masses of handsome flowers, and the coral and blue berries. The flowers are chiefly white, but in the European *Cornus mascula* are yellow. The forty or more small white flowers of the herbaceous bunchberry *Cornus canadensis*, gain conspicuousness by an involucre of four white bracts, sometimes tinged with red. I have also seen the leaves partially white. This species yields very little nectar, which can be detected only by close examination. The blooming season lasts for over a month, and the flowers are produced in the greatest profusion. I have watched these plants long and carefully, and have enumerated thirty-six visitors; but not once have bumblebees been seen to visit the blossoms, — a fact I attribute to the scarcity of honey. The shrubby species contain a more abundant supply of nectar. The cymes are large and very numerous, and not infrequently are sought by bumblebees. On *C. alternifolia* I have collected twenty-eight insects. There can be no doubt that the quantity and flavor of nectar is an element in the limitation of insect visits, but one that has received much less attention than

coloration. *C. florida* is provided with an involucre that is usually white, but varies to pink or red. The fruit is scarlet and the leaves are bright red in autumn.

SUMMARY.

1. Throughout the Choripetalæ, with few exceptions, conspicuousness is correlated with fertilization by insects. In the grape family the flowers depend upon their strong scent rather than upon bright coloring. In many genera it is possible to arrange the species in a progressive series, in which there is an advance from inconspicuousness, few visitors, and self-fertilization, to many visitors, great conspicuousness, and the loss of the power of self-fertilization. Pigments may be developed in all the organs of the inflorescence, as bracts, stems, sepals, petals, stamens, and pistils.

2. The green flowers of the Polypetalæ are small, and the petals are frequently wanting. The white and yellow flowers vary from small to large, are the most common, and contrast more strongly with the foliage than purple or blue. Of the seventy-one polypetalous families, forty-three contain white, forty-one yellow, and twenty-nine both kinds of flowers. White flowers are most common in families or genera containing shrubs and trees, small flowers aggregated in a dense inflorescence, and nocturnal flowers. Dark nocturnal flowers are strongly scented. Yellow flowers are more commonly herbaceous and are most abundant in the same families as white flowers, unless the species are shrubs or trees.

3. There is no evidence of the preference of beetles for flowers of any particular color. They do not avoid dull yellow. They are most common on small, white-clustered flowers with easily accessible honey and pollen. Diptera visit most frequently white and yellow flowers, but as they become more specialized and restrict themselves to flowers the percentage of visits to red and blue flowers increases. They appear to find a parti-colored, mottled, or dotted inflorescence, as in the Cruciferæ and Saxifragaceæ, attractive. Carrion flies prefer malodorous lurid-purple or flesh-colored flowers.

4. The changes of color and their sequence in individual flowers are noteworthy. Green changes to white (Cornus), to yellow (Thlaspi, Cardamine), to red (Hydrangea), to purple (Clematis), to violet (Cobæa); white changes to green (sepals of *Helleborus niger*), to yellow (Lantana), to red (Dianthus, *Hibiscus mutabilis*), to blue (many large blue flowers remain white until nearly ready to expand); yellow changes to white (Draba), to red (Æsculus), to blue (Myosotis); red changes to blue (Venetus and many Boraginaceæ); violet and blue may turn purple, green, or white in fading. The tendency of green, white, and yellow to change to red or blue is much stronger than the reverse.

5. The floral colors are often correlated with the colors of the stems and leaves, as in Sedum. The foliage of the plants with white flowers is, as a rule, paler than when the flowers contain pigments. The development of bright colors in autumn leaves presents a series of color changes, which are in part parallel to those which occur in flowers. With the disappearance of the chlorophyll the leaves become whitish, yellow, or red, according as the cells contain no pigment, or solid yellow granules, or red pigment dissolved in the cell sap. The leaves of many plants are yellowish green, due to the presence of a yellow pigment. Green, yellowish-green, and greenish-yellow flowers contain chlorophyll, and though usually small are occasionally of large size. Many white and yellow flowers are derived directly from the primitive green. White is usually a structural or optical color due to the unequal reflection and refraction of light by the intercellular air spaces and the cells devoid of pigment. White flowers are a less tax upon the energies of the plant. Flowers of all colors may revert to white, which is commonest in nature and most true to name under cultivation. If with the disappearance of the chlorophyll there is an insoluble yellow pigment in the cells, the petals are a pale yellow, and with its increase change to bright yellow or orange. The development of anthocyanin, or red pigment, dissolved in the cell sap, changes white flowers to red and yellow flowers to scarlet. With a decrease in the acidity of the cell sap the red flowers become blue. Müller's observations led him to the conclusion that the

honeybee prefers blue, violet, various shades of purple and red, to white and yellow, and avoids scarlet and lurid colors.

6. The formation of pigments is effected by the chemical composition of the soil, by altitude or the intensity of light, by latitude, and by the absence or presence of moisture, as well as other ecological forces. The particular coloration of flowers is largely a chemical problem.

The Colors of Northern Polypetalous Flowers.

Orders.	Families.	Green.	White.	Yellow.	Red.	Purple.	Blue.	Total.
Ranales	Nymphæaceæ		4	5	1	1		11
	Ceratophyllaceæ	1						1
	Magnoliaceæ		4	2				6
	Anonaceæ					1		1
	Ranunculaceæ	6	26	38	3	13	11	97
	Berberidaceæ		3	3		1		7
	Menispermaceæ	1	2					3
	Calycanthaceæ					2		2
	Lauraceæ	2		4				6
Papaverales	Papaveraceæ		5	10	6	2		23
	Cruciferæ	2	54	46	1	10		113
	Capparidaceæ		3	2	1	1		7
	Resedaceæ		1	2				3
Sarraceniales	Sarraceniaceæ			1		1		2
	Droseraceæ		4			1		5
Rosales	Podostemaceæ	1						1
	Crassulaceæ	2	2	5	2	2		13
	Saxifragaceæ	4	30	6		3		43
	Grossulariaceæ	4	6	1		2		13
	Hamamelidaceæ	1	1	1				3
	Platanaceæ	1						1
	Rosaceæ	4	35	39	13	4		95
	Pomaceæ		27		5			32
	Drupaceæ		20		1			21
	Mimosaceæ		3	1	2			6
	Cæsalpiniaceæ	2	1	7		1		11
	Krameriaceæ					1		1
	Papilionaceæ		39	33	13	88	24	197
Geraniales	Geraniaceæ		1		3	7		11
	Oxalidaceæ		1	6		1		8
	Linaceæ		1	6			2	9
	Zygophyllaceæ			2				2
	Rutaceæ	1	2					3
	Simarubaceæ	1						1
	Polygalaceæ		3	3	2	8		16
	Euphorbiaceæ	38	9	5	1			53
	Callitrichaceæ	4						4

The Colors of Northern Polypetalous Flowers.

(*Continued.*)

Orders.	Families.	Green.	White.	Yellow.	Red.	Purple.	Blue.	Total.
Sapindales	Empetraceæ					2		2
	Buxaceæ	1						1
	Limnanthaceæ		1					1
	Anacardiaceæ	7		1				8
	Cyrillaceæ	1						1
	Ilicaceæ		10					10
	Celastraceæ	3		1		2		6
	Staphyleaceæ		1					1
	Aceraceæ	5		3	1			9
	Hippocastanaceæ		1	3	1			5
	Sapindaceæ		2					2
	Balsaminaceæ			2				2
Rhamnales	Rhamnaceæ	5	3					8
	Vitaceæ	13						13
Malvales	Tiliaceæ		3					3
	Malvaceæ		4	5	13	4		26
Parietales	Theaceæ		3					3
	Hypericaceæ			22	2			24
	Elatinaceæ	4						4
	Cistaceæ	9		5				14
	Violaceæ		7	6		4	17	34
	Passifloraceæ		1	1				2
	Loasaceæ		2	3				5
Opuntiales	Cactaceæ	1		7	1	3		12
Thymeleales	Thymeleaceæ			1		1		2
	Elæagnaceæ			3				3
Myrtales	Lythraceæ	2				10		12
	Melastomaceæ				1	3		4
	Onagraceæ	3	14	24	10	6		57
	Trapaceæ		1					1
	Haloragidaceæ	6			1	6		13
Umbellales	Araliaceæ	2	3	1				6
	Umbelliferæ		58	16		1	3	78
	Cornaceæ	3	9	1		1		14
	Total	140	410	333	84	193	57	1217

NOTES AND LITERATURE.

ZOÖLOGY.

Shipley and MacBride's Zoölogy.[1] — It may be said in beginning that this is among the best of text-books for elementary college classes in zoölogy. It is fresh, clear, well arranged, and fairly accurate. In its first twelve pages it outlines the basal facts of zoölogy, or better of morphology, including short statements concerning life, protoplasm, and the theory of evolution, and then begins the systematic portion of the volume. The Protozoa come first; then, in order, the Cœlenterata, Porifera, and Cœlomata, — this latter division ending with man. As a result, the flatworms, rotifers, nematodes, etc., appear in the most unexpected place, — the end of the volume. There does not appear any hint that there is a question as to the validity of the cœlom or its use as a basis of classification. In the treatment of each group the authors follow the well-known English model of giving, first a detailed description of some form selected as a type, then a general statement, followed by too brief and inadequate an outline of classification.

Good as the book is as a whole, we find here and there parts which cannot have our full acceptance. In the earlier portions the authors have succeeded well in their attempt, as avowed in the preface, to produce "an elementary treatise on zoölogy which could readily be understood by a student who had no previous knowledge of the subject," but in the later portions, and especially in the treatment of the vertebrates, they fall far short of their ideal. No student, for instance, could gain from these pages, without outside assistance, any adequate idea of the skull or the nephridial system. As the whole work seems so well done, it is hardly just to publish a long list of questionable or erroneous statements which would seem to contradict the good opinion already expressed; and yet, directing attention to some of these shortcomings may lead to their correction in the subsequent editions, which will certainly follow.

[1] Shipley, A. E., and MacBride, E. W. *Zoölogy, an Elementary Text-Book.* New York, The Macmillan Company, 1901. xxi + 632 pp.

In dealing with the arthropods we object to the violent divorcing of the closely allied Crustacea and arachnids by shoving the insects between them. The conception of a crustacean head composed of five segments is unwarranted, and the retention of the group Myriapoda, in view of the work of Pocock, is indefensible, while the statement (p. 193) that Limulus occurs on our Pacific coast is erroneous. We do not believe that *Helix aspersa* is acclimated in this country to the extent implied on page 198, and on page 221 the terms "squid" and "cuttlefish" are transposed. On page 241 there is an erroneous explanation of the way in which the starfish opens clams and mussels, and we are not inclined to accept the statement (p. 221) that there are over five hundred species of Unionidæ in North America. Certainly many of the species enumerated by Conrad, Lea, and others are not entitled to any such rank.

In their account of the vertebrates the authors have attempted to carry too far homologies between the true vertebrates and the other chordate forms. For instance, the anterior head cavities of the shark cannot be compared to the proboscis cavity of Balanoglossus; and, by the way, what do the authors mean (p. 293) when they relegate the term "Balanoglossus" to the category of popular rather than generic names? On page 332 there is an erroneous conception of the pharynx, no portion of which is stomodeal; the idea of a gonotome (p. 343) has been vigorously combated, and certainly, in view of the comparatively recent researches of Rabl, the pronephric duct should not be described (pp. 342, 352), without a question, as ectodermal in origin. It certainly harmonizes with some theories, but —. Not all Dipnoi (p. 371) have two lung sacs, while some Cæcilians (*e.g.*, Ichthyophis) do have a ductus Botalii (p. 437). Again, it is certainly questionable whether Gadow's conception of the structure of a vertebra (p. 378) is correct; and the statements (p. 330) concerning the optic nerve need revision in the light of the results of Keibel, Assheton, and others, for these nerves are clearly not the stalks uniting the primary optic vesicles with the brain, but true nerves which replace them. There is also a complete crossing of the fibers in the lower vertebrates. The division of birds into Ratitæ and Carinatæ (p. 497) should not be kept up in this year 1901. In view of the statement that the vertebræ of mammals "have no cup-and-ball articulations with one another" (p. 510), we should advise an examination of the cervicals of a horse, and (p. 404) would call attention to the fact that several amphibians have amphicœlous vertebræ.

Here and there the English used is not beyond question, being sometimes inelegant, sometimes confused. The term "urinogenital" has been cast into limbo by Huxley (*Life and Letters*, Vol. II, p. 65), but language is a dangerous thing to discuss. So much depends upon the point of view, and our authors have occupied a peculiar position for seeing things, as we learn from the legend of Fig. 200, which represents the right half of a lamprey "seen from the inside of a female specimen." The mechanical part of the work is well done, and the illustrations, mostly zinc etchings, are clear, and as a rule bring out well the points made in the text.

K.

Notes. — Wallengren (*Jenaische Zeitschrift für Naturwissenschaften*, Bd. XXXVI, pp. 165–180, Taf. VII–VIII) gives a brief but interesting account of the innervation of the proboscis of some of the polychæte worms. The sense cells always occur in the papillæ of the proboscis, never on the surface between papillæ. In Nephthys and Phyllodoce they are radially arranged within a papilla, but in Glycera and Goniada they are grouped into multicellular organs, and single sense cells do not occur. In all cases the distal ends of the sense cells pierce the superficial cuticula, and in Glycera at least they end externally in a brushlike expansion. Proximally the fiber from each cell body either passes undivided to the central organs, as in Nephthys, or gives off branches at the base of the papillæ, forming a subcutaneous nerve plexus as in Glycera. No observations were made on the functions of these organs.

The ganglion cells of the electric lobes in the Torpedo are said by Hatai (*Journal Cincinnati Society of Natural History*, Vol. XX, pp. 1–12, Pl. I) to show an apparent fibrillar structure such as that described long ago by Max Schultze. Bundles of fibrils seem to enter the cell from the dendrites as well as from the neurite. This appearance, however, is due to the form of the protoplasmic reticulum, the meshes of which are much drawn out in the regions of the cell processes, and does not indicate the presence of true nerve fibrillæ. While the bundles of fibrillæ as described by Schultze are thus explained away, those discovered by Bethe and Apàthy belong to another category and probably are real structures. Gradations from the ordinary mesh work to the mesh work with fibrillar appearance have been described by Hatai in the spinal ganglion cells of the white rat.

An ingenious method of recording egg development for the use of fish culturists has been devised by C. Wallich (*United States*

Fish Commission Report for 1900, pp. 185–194). It is well known that fish eggs develop much more rapidly in warm water than in cold, and when, as is often the case, the temperature of the water at a hatching station varies from day to day, it is often difficult to estimate the stage of development reached by a given lot of eggs. This difficulty can be overcome by the use of the temperature unit system. By a "temperature unit" is meant one degree Fahrenheit above 32° F. for one day. Thus 36° F. for a day is equivalent to four temperature units. In any lot of eggs the stage of development is recorded by adding the temperature units to which they have been subjected since fertilization. The success of such a system depends upon the uniformity of its results. As judged from the experiments on salmon at the government station at Baird, Cal., the method gives a close approximation to uniformity. In something over fifty lots of salmon eggs, in which the incubation period varied from forty-eight to ninety days, the greater number of eggs hatched at about nine hundred temperature units, the extremes being 874 and 940. The utility of this method, not only to fish culturists but also to embryologists, is evident.

C. E. Beecher has contributed to the series of Yale Bicentennial Publications a volume entitled *Studies in Evolution* (New York, Charles Scribner's Sons, 1901). The volume is made up mainly of reprints selected from the publications of the Laboratory of Invertebrate Paleontology at Yale, and contains studies on the origin and significance of spines, on the structure and development of trilobites, and on the development of brachiopods. Most of the papers have already appeared in various journals, but their collection into a single volume will be welcomed by advanced students, not only as evidence of the work done at Yale, but as an indication of the new fields into which modern paleontological research is making its way.

The stony corals of the Porto Rican waters have been reported upon by T. W. Vaughan (*United States Fish Commission Bulletin for 1900*, Vol. II, pp. 289–320, Pls. I–XXXVIII). About twenty-five species are recorded and beautifully illustrated by process plates from photographs.

C. W. Hargitt and C. G. Rogers give an account of the Alcyonaria of Porto Rico (*United States Fish Commission Bulletin for 1900*, Vol. II, pp. 265–287, Pls. I–IV). Some twenty-five species are reported, of which five are new.

A descriptive catalogue of the mollusks of Porto Rico, with a check list of species, has been prepared by W. H. Dall and C. T. Simpson (*United States Fish Commission Bulletin for 1900*, Vol. I, pp. 351–524, Pls. LIII–LVIII). In all, about 650 species are recorded, of which forty-two are new. The report is illustrated by excellent figures, and has a good index.

BOTANY.

The Yearbook of the Department of Agriculture.[1] — The growing size, complexity, and activity of the national Department of Agriculture has led to attempts to simplify its publications by the establishment of series accredited to the several divisions and more or less closely pertaining to the nominal work of the latter; and a few years ago the secretary had the happy idea of confining the annual volume — before that called a *Report* — to an administrative and scientific summation of the year's work, under the title *Yearbook*. Difficulty appears to have been experienced in carrying out this idea, however, and the *Yearbook* has once more approximated its former size and character, notwithstanding the voluminous annual aggregate of bulletins and circulars published from the several divisions. In addition to the report of the secretary and an appendix of over two hundred pages, collectively constituting the report proper, the *Yearbook* for 1900 includes a biographic sketch of the late William Saunders, for many years connected with the care of the grounds and plant houses of the Department, and no less than thirty special articles, on such subjects as Smyrna fig culture, date culture, practical foresty in the southern Appalachians, etc., — all of interest and value.

T.

Britton's Manual.[2] — The most potent means of impressing ideas or facts on the public mind lies in their concrete presentation in such form as to insure ready accessibility and invite frequent reference. When, in 1892, the American botanists assembled at Rochester adopted a nomenclature codification which involved extensive changes

[1] *Yearbook of the United States Department of Agriculture*, 1900. Washington, Government Printing Office, 1901. 888 pp., 87 pls., and numerous figs.

[2] Britton, N. L. *Manual of the Flora of the Northern States and Canada.* New York, Henry Holt & Co., 1901. x + 1080 pp.

in the Latinized names of our higher plants, they insured the most rapid possible introduction of the proposed changes by taking steps for the compilation and publication of a check list in which these changes should appear; and the frequent adoption of the names approved by the authors of that list, in general and local botanical papers, and their subsequent application through the large *Illustrated Flora* of Britton and Brown, have made them generally familiar, — to the pleasure of some and the great regret of other botanists, both at home and abroad. With the changes in names have also come a change in the way of viewing species and increased attention in the field to the divisibility of species which scarcely admitted of a satisfactory knowledge from herbarium material.

To meet these needs and changed conditions the *Illustrated Flora* was prepared; and yet it was too bulky and, notwithstanding its remarkable cheapness, too costly for the fullest desirable uses. Because of these reasons, Dr. Britton, the active editor of the *Flora*, set to work to prepare a more condensed manual with the same purpose and limits as the *Flora*, and it now appears in a convenient and — for this class of book — attractive form, and is undoubtedly destined to have a wide sale and to serve a good purpose. That it will lead to a recognition of many valid species of the region covered, not recognizable by use of the familiar *Manual* of Dr. Gray, is certain, and that it will ultimately replace the latter in general use is not improbable, though the present writer would recommend the use of the two conjointly, rather than of either by itself.

T.

Vegetable Pathology.[1] — Almost from the installation of the first agricultural experiment station, the diseases of plants have been a fruitful and legitimate subject for investigation, and the selection of a station botanist has more than once hinged on his fitness to become the plant pathologist at the same time. Yet the efforts of investigators have been largely turned to the study of the life histories of parasitic fungi and the means of directly combating them, rather than to the fundamental study of pathology itself. No one who takes the trouble to read Professor Marshall Ward's presidential address before the botanical section of the British Association, delivered a few years ago, can fail to be impressed by his familiarity with the details of applied botany, and the volume before us marks a distinct advance in knowledge and points the way for the establishment of

[1] Ward, H. Marshall. *Disease in Plants.* London, Macmillan & Co., 1901. xiv + 309 pp.

an art of plant therapy, if this is ever to be possible or worth the establishment.

The Flora of Tennessee.[1] — No living botanist is as familiar with the interesting plants of Tennessee as the venerable Dr. Gattinger, who, like the late Dr. Mohr of Alabama, has spent many years in field study and now brings together the results of his work. Tennessee is a state of diversified topography, and the systematic list is preceded by a discussion of the factors which influence plant distribution. Like Dr. Mohr, Dr. Gattinger adapts himself to the Neoamerican practices in nomenclature and to the phylogenetic classification of the Germans, though not without a word of protest. Whether or not he be followed in his philosophic ideas, they contain the kernel of much that is good.

The Grasses of Iowa.[2] — In the prefatory note to this book Professor Calvin, the state geologist, tells us that the law creating the Iowa Geological Survey provides for the publication of bulletins on subjects of economic interest relating to the natural history of the state, and this consideration of one of the most important economic groups of plants forms the first of such bulletins. The topics treated are: the general structure and physiological characters of Gramineæ; purity and vitality of grass seed; cereals; fungus and bacterial diseases of grasses; the pastures and meadows of Iowa; weeds of meadows and pastures; chemistry of foods, and feeding; and lawns and lawn-making in the state. Professors Pammel and Weems are well equipped by training and opportunity for the consideration of these topics, and it is understood that the systematic discussion of the group, for which Professor Lamson-Scribner will be largely responsible, is to constitute a second volume complementary to the one now used.

Chlorophyll.[3] — No. 10 of the biologic series of *Scientia* presents in a manner not too technical for the layman the main facts concerning the chlorophyll function in plants as carried on under various external conditions. The structure, as well as the function, undergoes adaptive modifications in response to these conditions, and the

[1] Gattinger, Augustine. *The Flora of Tennessee, and a Philosophy of Botany.* Nashville, 1901.

[2] Pammel, L. H., Weems, J. B., and Lamson-Scribner, F. *The Grasses of Iowa.* Des Moines, 1901. 525 pp., 220 ff.

[3] Griffon, Ed. L'assimilation chlorophyllienne et la structure des plantes, *Scientia*, Biologie, No. 10. Georges Carré et C. Naud, Éditeurs. Paris.

author here traces these effects of the environment. Means of measuring photosynthetic activity described in the first chapter are applied to the study of this form of activity in saprophytes and parasites and to the effect of light, temperature, moisture, and mineral salts on this function in green plants having a normal nutrition. R. H. T.

Our Forests. — Popular interest in the preservation of forests is too often a matter of extremes, so diverse reasons as pure emotion or simple business considerations leading to the wish for their protection, while private greed is ever encroaching on them in the most ruthless fashion. A most attractive presentation of the subject from the æsthetic standpoint is made in a little book by G. F. Schwarz.[1] A pleasingly written commentary on a few selected trees representative of our deciduous and coniferous woods is followed by chapters on forest adornment, the distribution of American forests, the characters of the broad-leaf and coniferous forests, and the artificial forests of Europe. Throughout, the book is well illustrated by process cuts. It is neither botany nor forestry, but a delightful presentation of the beauties of nature as exemplified in forests, equally correct in treatment when viewed from either of these special points of view, and calculated to draw increased attention to the desirability of holding as tenaciously as possible to what is still left of this most charming phase of nature. T.

The Annals of the Calcutta Garden.[2] — Like its predecessors, this volume is not only well brought out, but of permanent value, and the authors, Messrs. King, Duthie, and Prain, are to be congratulated on it. The plates are lithographed, and an excellent photogravure representing *Albizzia Richardiana* serves as frontispiece. T.

Notes. — In the *Bulletin of the Torrey Botanical Club* for December Miss Eastwood describes several new Delphiniums from California.

A paper on seed coats of certain species of Brassica, including good anatomical figures, by A. J. Pieters and V. K. Charles, is published as *Bulletin 29 of the Division of Botany of the United States Department of Agriculture.*

[1] Schwarz, G. F. *Forest Trees and Forest Scenery.* New York, The Grafton Press, 1901. xiv + 183 pp.

[2] *Annals of the Royal Botanic Garden, Calcutta.* Vol. ix, pt. i, A Second Century of New and Rare Indian Plants. Calcutta, The Bengal Secretarial Press, 1901. 82 pp., 94 pls. £1 13*s*.

Hefte 11–12 of Abtheilung I of the 1901 volume of the *Botanische Zeitung* consists of a paper by Hannig on the septal wall of the fruit of Cruciferæ.

Professor Hildebrand contributes biological notes on *Jeffersonia diphylla* and *Apios tuberosa*, as well as other species not of our flora, to No. 8 of the current volume of *Berichte der deutschen botanischen Gesellschaft.*

Schlotterbeck and Eckler publish a paper on fruit structure and development of *Illicium floridanum* in the *Pharmaceutical Archives* for November.

The Celastraceæ of China are undergoing revision by Loesener in Engler's *Botanische Jahrbücher*, which, as usual of late, is for the most part devoted to African plants.

The development of the seed and the differentiation of the protective testa in several Sapindaceæ is discussed by Guérin in the October number of the *Journal de Botanique.*

A monograph of the leguminous genus Dorycnium, by Rikli, is published in Heft 3 of Engler's *Botanische Jahrbücher*, Vol. XXXI.

A case of parthenogenesis in Alchemilla is described by Murbeck in Vol. XXXVI of *Acta Universitatis Lundensis*, which also contains an article by the same author on chalazogamy, in connection with a further study of the same genus.

In *Torreya* for December Mr. Small publishes a new Texan cherry, under the name *Prunus eximia.*

Spiræa millefolium is figured in *Curtis's Botanical Magazine* for December.

Those accustomed to seeing *Cereus peruvianus* as it is commonly cultivated in plant houses will be interested in an open-air portrait of it as grown at Monte Carlo, published by Becker in *Die Gartenwelt* of December 21.

Opuntia monocantha, *O. glauca*, and *O. engelmanni*, which prove hardy in the botanical garden of the University of Cambridge, are figured in the *Gardeners' Chronicle* of December 7.

An illustrated account of the cacti found to be hardy in Giessen is given by Rehnelt in *Die Gartenwelt* of December 14.

The affinities of the Valerianaceæ and Dipsaceæ are discussed by Höck in Vol. XXXI, Heft 3, of the *Botanische Jahrbücher.*

In the number of the *Proceedings of the Washington Academy of Sciences* issued December 6, Mr. Coville separates from the genus Cassiope the species which have been known as *C. oxycoccoides*, *C. stelleriana*, and *C. hypnoides*, proposing for the first the generic name Arcterica, and for the last two the generic name Harrimanella, in honor of Mr. E. H. Harriman, of whose Alaskan party Mr. Coville was a member.

In *Rhodora* for November Walter Deane indicates a form *leucocarpum* for *Vaccinium pennsylvanicum;* a similarly named form for *V. corymbosum atrococcum* and a form *chiococcum* for *V. canadense* are indicated for New England.

The inelegant compound inflorescence often produced by the Edelweiss under cultivation, and which is then the despair of gardeners, is the subject of an illustrated article by Brunotte in the *Revue Générale de Botanique* of October 15.

The four United States forms of Leontodon are reviewed by Fernald in *Rhodora* for December.

In *Rhodora* for December Mr. Ames describes an artificially produced hybrid of *Lobelia inflata* ♀ × *L. cardinalis* ♂.

Euphrasia, as it occurs in North America, is reviewed by Dr. Robinson in *Rhodora* for November. *E. williamsii*, *E. randii*, *E. randii farlowii*, and *E. americana canadensis* are new names.

The west-coast Solanums of the group of *S. umbelliferum* are revised by Parish in No. 5 of the current botanical volume of *Proceedings of the California Academy of Sciences.*

For various species commonly placed in Bartonia or Mentzelia, Cockerell proposes the generic name Hesperaster, in *Torreya* for December.

Hefte 5 and 6 of Engler's *Das Pflanzenreich*, devoted respectively to Rafflesiaceæ and Hydnoraceæ by Sohns-Laubach, and Symplocaceæ by Brand, were issued November 5.

Anatomical studies of certain Australian Podalyrieæ, by Hühner, constitute Heft 3 of the current volume of the *Beihefte zum botanischen Centralblatt.*

A paper by G. N. Collins, on seeds of commercial saltbushes, constitutes *Bulletin 27 of the Division of Botany of the United States Department of Agriculture.*

A synopsis of the palms of Puerto Rico, with much extra-limital matter, by O. F. Cook, is published, with illustrations, in the October *Bulletin of the Torrey Botanical Club.*

Habit and detail figures of *Jubæa spectabilis* are published in the *Revue Horticole* of January.

In the *Bulletin de la Société Botanique de France*, Nos. 5–6 of the current volume, Gagnepain publishes a revision of the zingiberaceous genera Mantisia and Globba, as represented in the herbarium of the museum at Paris. Several new species are described and figured.

In the *Revue Horticole* of December 16 a new Pitcairnia, *P. micheliana*, from Mexico, is described and figured by André.

As No. 4 of the current botanical volume of *Proceedings of the California Academy of Sciences*, is published a revision of the genus Calochortus, by Carl Purdy.

In the November *Bulletin of the Torrey Botanical Club*, Dr. Rydberg monographs the species of his orchidaceous genera Limnorchis and Piperia, occurring north of Mexico.

The southwestern species of Sisyrinchium are passed in review by Mr. Bicknell in the October *Bulletin of the Torrey Botanical Club.*

Prof. H. Marshall Ward's handbook of grasses, recently issued from the University Press of Cambridge, is a convenient little work, with keys based on vegetative characters, leaf anatomy and fruit, as well as the more usual flower and inflorescence characters.

A paper by Holm on new anatomical characters for certain Gramineæ is published in Vol. XI, Heft 2, of the *Beihefte zum botanischen Centralblatt.*

One of the most important recent cytological papers is by Dr. Webber on spermatogenesis and fecundation of Zamia, presented as a thesis for the doctor's degree at Washington University last season, and now printed as *Bulletin No. 2 of the Bureau of Plant Industry of the United States Department of Agriculture.*

A paper by Worsdell on comparative anatomy of the Cycadaceæ forms Part II of the current volume of *Transactions of the Linnean Society of London.*

A paper on the red cedar, prepared by Dr. Mohr shortly before his death, has recently been published as *Bulletin No. 31 of the Division of Forestry of the United States Department of Agriculture.*

A specimen of *Araucaria cookii*, coning in the temperate house at the Kew Gardens, is figured in the *Gardeners' Chronicle* of November 30.

The New England form of *Lycopodium complanatum* is named var. *flabelliforme* by Fernald in *Rhodora* for November.

B. D. Gilbert publishes a note on *Lycopodium tristachyum* in *Torreya* for October.

J. H. Faull contributes an account of the anatomy of Osmundaceæ to the *Botanical Gazette* for December.

The account of the mosses of the "Belgica" expedition to the extreme South, by Cardot, occupies a quarto pamphlet of 48 pages, illustrated by 14 plates, published by the Belgian government.

Pseudoleskea artariæ and *Leskea obscura* are comparatively described by Thériot in a paper reprinted from the *Recueil de la Société Havraise d'Études Diverses* for 1901.

An extensive and well-illustrated paper on Alaskan algæ, by De Alton Saunders, constitutes No. 25 of the "Papers from the Harriman Alaska Expedition" in course of publication in the *Proceedings of the Washington Academy of Sciences*. The catalogue includes 380 species, of which 240 are new to Alaska. Nine new species and one new genus (Pleurophycus, Setchell and Saunders) are described.

Lemaire, who has been studying the micro-chemistry of the sheath of the blue-green algæ, states, in the recent numbers of the *Journal de Botanique*, that in Anabæna, Nostoc, and some other genera the mucilaginous sheath consists of a pectic compound, which, in the case of some species of Scytonema and Phormidium, is associated with another substance, which he calls "schizophycose," the latter, in some species of Scytonema, Tolypothrix, etc., being further associated with cellulose.

The Diatomaceæ of the Hull district are listed and figured in No. 4 of the *Transactions of the Hull Scientific and Field Naturalists' Club*, issued in December.

The cultivation of mushrooms is usually effected by the use of spawn either grown in mushroom beds or derived from compost piles or similar sources. In 1896 Costatin and Matruchot published interesting details of methods of securing pure and unquestionable spawn or mycelium of a few forms, and in the *Revue Générale de Botanique* of November 15 last they further describe their method of obtaining pure commercial cultures of *Tricholoma nudum*.

The modes of preserving pileate fungi without loss of their natural colors are reviewed by Lutz in the December *Bulletin de la Société Mycologique de France.*

Heft 9 of Schimper's *Botanische Mittheilungen aus den Tropen* consists of Alfred Möller's studies on Brazilian phycomycetous and ascomycetous fungi, and is fully and well illustrated.

No. 44 of the *Korrespondenzblatt des Naturforscher-Vereins zu Riga* contains a list of the twelve truffles occurring in the Baltic district.

In No. 8 of his serial *Mycological Notes*, Mr. C. G. Lloyd figures several species of Scleroderma, Geaster, and Mycenastrum.

Dr. Thaxter's epoch-marking work on Laboulbeniaceæ furnishes the text for a popular article by Mr. Massee in the November number of the *Journal of the Quekett Microscopical Club.*

The genus Fusarium, which includes several species growing on dead animal matter of various sorts, receives an interesting addition under the name *F. equinum*, described in *Science* of December 6 by Növgaard as occurring in the hair follicles and sebaceous glands of horses in Oregon.

A monograph of the genus Aspergillus, by Wehmer, is separately published from the *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, Vol. XXXIII.

In the *Bulletin of the Torrey Botanical Club* for December, Professor Arthur publishes descriptions of a considerable number of new Uredineæ.

The effects of Rhizoctonia on the potato plant are discussed in *Science* for December 6, by F. M. Rolfs.

The fungi causing spot diseases of the cherry, etc., are discussed in an illustrated article by Aderhold in the December number of *Landwirtschaftliche Jahrbücher.*

Leaf diseases of the currant are considered by Stewart and Eustace in *Bulletin No. 199 of the New York Experiment Station.*

PETROGRAPHY.

"Perknite," a New Rock Term. — Turner,[1] in a recent article, suggests the use of the term "perknite" as the designation of coarse-grained lime-magnesia rocks composed essentially of monoclinic

[1] *Journ. Geol.*, vol. ix (1901), p. 507.

pyroxenes and amphiboles. The group of the perknites would include pyroxenites, hornblendites, and hornblende-pyroxene aggregates. It would include also websterites and similar aggregates in which monoclinic amphiboloids predominate. The augitites and some of the hornblende-picrites are the corresponding effusive types. Analyses of some of the author's characteristic perknites follow :

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	Various
I.	46.28				19.54	9.91	2.21	1.89		
II.	48.04	7.82	2.01	9.32	13.33	13.01	.69	.48	3.07	2.74 = 99.51
III.	48.63	5.32	2.91	3.90	21.79	13.04	.34	.23	2.81	1.16 = 100.13
IV.	50.80	3.40	1.39	8.11	22.77	12.31	tr	tr	.52	.73 = 100.03
V.	53.25	2.80	.69	5.93	19.91	16.22	.19	tr	.29	.70 = 99.98
VI.	53.21	1.94	1.44	7.92	20.78	13.12	.11	.07	1.01	.87 = 100.47

I. Hornblendite. Dyke near Silver Peak Village, Esmeralda County, Cal.
II. Amphibole-pyroxene rock. Abundant in Mariposa County, Cal.
III. Perknite (peridotite). Belchertown, Mass.
IV. Pyroxenite. Johnny Cake Road, Baltimore, Md.
V. Websterite. Mt. Diablo, Cal.
VI. Websterite. Oakwood, Cecil County, Md.

Shonkin Sag; A Study in Differentiation. — Shonkin Sag is a flat laccolite rising from the plains southeast of the Highwood Mountains, Montana. It has afforded Weed and Pirsson[1] excellent opportunities for the study of the differentiation of a magma in place, since it is dissected by a stream valley formerly occupied by a branch of the Missouri River. Examination of the sections exposed to view indicate that the igneous portion of the laccolite consists of concentric shells of leucite-basalt, skonkinite, a transition rock composed of groups of large augite crystals and long slender foils of biotite with white feldspathic material between, and syenite, with the last-named rock in the center. The various rock types grade into one another without discernible breaks between them. The facts suggest to the authors "that the body of the magma forming the laccolite must have been injected as a whole, in a homogeneous condition, and that the rearrangement and formation of the various parts followed within the mass itself. . . . The first stages of cooling and crystallization against the outer envelope of sedimentary rocks was relatively more rapid than that affecting the inner portion, and resulted in producing the outer porphyritic shell." There was, further, a gradual withdrawal and concentration of feldspathic material toward the inner portion of the mass and an enrichment of the outer zone with lime, iron, and magnesia, thus producing the concentric arrangement of the rock types.

[1] *Amer. Journ. Sci.*, vol. xii (1901), p. 1.

Basic Rocks in Maryland. — A series of acid and basic rocks intrude the gneisses of northeastern Maryland, and these in turn are cut by extensive dykes of granite and pegmatite. The principal types are biotite granite, diorite, tonalite, norite, hypersthene-gabbro, pyroxenite, peridotite, and serpentine. The order of eruption seems to have been norite and gabbro, diorite and granite. The last two rocks are connected by gradation phases, and this is thought to be evidence that their difference in age is not great. The peridotites and pyroxenites are mainly younger than the norites and gabbros, but some of the pyroxenites are apparently peripheral phases of the norite.

The succession taken as a whole is supposed to "furnish an example of the occurrence of several rock types which represent the facies of a single magma and unite to form a geological unit."

The serpentines were derived partly from the peridotites and partly from the pyroxenites. In the latter change the hypersthene and diallage first alter into fibrous hornblende, and this later passes into the serpentine. The area is very similar in its essential features to the Delaware area of gabbros described by Chester and the Baltimore area described by Williams. The distinguishing features of the present area are (1) the abundance of diorite, (2) the comparative rarity of gabbro-diorite, and (3) the great abundance of pegmatite and granite dykes.[1]

Rock Structure. — The study of a series of andesitic and rhyolitic rocks that occur as extrusives in the Great Basin region suggests to Spurr[2] that the differences in structure of igneous masses may be brought about by slight changes in conditions under which crystallization took place. Among the differences which affect structure may be mentioned slight changes in the rate of cooling. Textural variations are less common in acid than in basic extrusives because in the latter the viscosity varies more rapidly with rapid cooling than in the former. The more important structures are not characteristic of particular rocks, but are the functions of the relation between viscosity and cooling rate. Structure therefore cannot, according to the author, be made the principal element in rock classification.

[1] Leonard, A. G. *Amer. Geol.* (1901), p. 135.
[2] *Journ. Geol.*, vol. ix (1901), p. 586.

CORRESPONDENCE.

To the Editor of the American Naturalist:

SIR: — In that very interesting and not unimportant book *Memoirs of Odd Adventures, Strange Deliverances, etc., in the Captivity of John Giles, Esq. . . . written by himself,* describing his captivity among the Indians of New Brunswick in 1689–98, occur many quaint but truthful remarks upon the habits of common animals. But among the others occurs this:

Of the Tortoise. It is needless to describe the fresh-water tortoise, whose form is so well known in all parts: but their manner of propagating their species is not so universally known. I have observed that sort of tortoise whose shell is about fourteen or sixteen inches wide. In their coition they may be heard half a mile, making a noise like a woman washing her linen with a batting staff. They lay their eggs in the sand, etc.

I have asked several students of these animals for information about the noise here mentioned, but none of them seem to know it. Giles (or more properly Gyles) is usually so accurate in his observations that I can hardly believe he was wholly mistaken in this case. Can any of the readers of the *American Naturalist* throw any light upon the subject?

The immediate reason for my interest in the matter is an inquiry from my friend Mr. Victor H. Paltsits, of the Lenox Library, New York City, who is editing and exhaustively annotating a new edition of Gyles's Memoirs, soon to be published by Dodd, Mead and Co. of New York.

W. F. GANONG.

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